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WATER QUALITY MANAGEMENT - TRAINING COURSE MANUAL

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

March 1965

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WATER QUALITY MANAGEMENT

215176

TRAINING COURSE MANUAL

Environmental Sciences and Engineering

Radiological Health
Air Pollution
Water Supply and Pollution Control
Environmental Engineering and Food Protection
Occupational Health

U.S. Department of Health, Education, and Welfare
Public Health Service

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WATER QUALITY MANAGEMENT

This course is designed specifically for sanitary engineers and others with responsibilities in the administration of water quality management programs. The training course manual has been specially prepared for the trainees attending the course and should not be included in reading lists or periodicals as generally available.

Conducted by
Water Supply and Pollution Control Training
TRAINING PROGRAM

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Bureau of State Services
Division of Water Supply and Pollution Control

Robert A. Taft Sanitary Engineering Center
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March, 1965

TRAINING PROGRAM

The Public Health Service, U. S. Department of Health, Education, and Welfare, conducts programs of research, technical assistance, and training in environmental health at the Robert A. Taft Sanitary Engineering Center in Cincinnati. Scientists and engineers in the Divisions of Water Supply and Pollution Control, Air Pollution, Radiological Health, and Environmental Engineering and Food Protection seek to determine the sources and effects of contamination and to develop new and improved methodology for the identification, treatment, and control of causative factors.

As the national growth accelerates, problems of the environment increase both in magnitude and complexity. A concomitant advance in scientific knowledge results in widespread technological changes. Programs in the environmental health field are developing so rapidly that the call for trained people exceeds the number available. Although both public and private agencies are expanding their training efforts, more people must be trained in the new technologies if health programs are to achieve their purpose.

It is the function and major objective of the Training Program to provide the specialized training necessary to shorten the gap between the development of new technologies and their application by professional people working in the field. The Divisions increasingly utilize the Training Program for training new personnel assigned to their many functional areas.

To meet this objective, courses are designed and conducted by a full-time staff of experts. Center scientists and engineers and recognized authorities from other government agencies, universities, and industry supplement the training staff by contributing their knowledge and experience as lecturers and consultants.

The courses provide intensive, highly specialized training, usually at the graduate level. They are conducted in the Center classrooms and laboratories and at regional locations. Training Institutes, conducted cooperatively with Public Health Service Regional offices, universities, and interested agencies, provide a unique means of reaching large numbers of personnel at one time with joint programs of concurrent courses.

The Training Program arranges the schedules of visitors from foreign countries who come to the Center for training and consultation. It originated and conducts the Analytical Reference Service, a cooperative membership of agencies concerned with evaluation of environmental laboratory methodologies.

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WATER QUALITY MANAGEMENT
March 1 - 12, 1965

AGENDA

A "Symposium" on the Broad Aspects of Water Quality for Professional Management

Moderators: I. Bernstein
P. W. Weiser
P. F. Atkins

DAY & TIME	SUBJECT	OUTLINE NO.	SPEAKER
Monday, March 1			
8:30 - 8:45	Registration		I. Bernstein
8:45 - 9:00	Welcome - SEC Activities		H. P. Kramer
9:00 - 9:15	Welcome - Training Activities		J. P. Sheehy
	BASIN PROGRAMMING CONCEPTS: 9:30 - 12:30		L. B. Dworsky (Moderator)
9:30 - 9:50	Basin Planning Goals	1	L. B. Dworsky
9:50 - 10:10	Public Health Service Role in Comprehensive Basin Programming	2	R. W. Haywood
10:10 - 10:35	A Perspective on Water Pollution Control Administration	5	E. J. Cleary
10:35 - 11:00	A Current Basin Study	3	R. A. Vanderhoof
11:00 - 11:20	State Role in Basin Programming	4	S. L. Frost
11:20 - 11:40	Corps of Engineers Role in Basin Programming		W. Brewer
11:40 - 12:30	Panel Discussion: Basin Programming Concepts W. Brewer R. A. Vanderhoof E. J. Cleary S. L. Frost R. W. Haywood		
12:30 - 1:30	Lunch		
	INCREASING IMPORTANCE OF GROUND WATER: 1:30 - 4:30		L. M. Klashman (Moderator)
1:30 - 1:50	Ground and Surface Water Relationships	6	L. M. Klashman
1:50 - 2:10	Ground Water Potential and Development	7	M. Deutsch
2:10 - 2:30	Naturally Occurring Water Quality Problems	8	F. Rainwater
2:30 - 2:50	Groundwater Protection During Wastewater Application	9	T. W. Bendixen
2:50 - 3:10	A State Program for Ground Water Protection	10	G. H. Emrich

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3:25 - 4:30	Panel Discussion: Increasing Importance of Ground Water T. W. Bendixen, G. H. Emrich M. Deutsch, F. Rainwater D. L. Warner		
Tuesday, March 2			
	QUALITY CRITERIA FOR DOMESTIC, RECREATIONAL AND AQUATIC LIFE USES: 8:15 - 11:15		G. W. Burke (Moderator)
8:15 - 8:30	Objectives of Water Quality	11	G. W. Burke
8:30 - 8:45	Basis for Microbiological Criteria	12	H. F. Clark
8:45 - 9:00	Criteria for Water in Aquatic Life Use	13	C. M. Tarzwell
9:00 - 9:15	Ultimate Goals in Chemical Criteria	14	E. L. Bean
9:15 - 9:30	Recreational Standards and Needs	15	A. Hirsch
9:45 - 10:00	Conservationists' Views	16	W. E. Towell
10:00 - 10:15	Toxicologic Perspective on the Total Impact of Chemical Environmental Pollutants on Human Health	17	H. E. Stokinger
10:15 - 11:15	Panel Discussion: Quality Criteria for Domestic, Recreactional and Aquatic Life Uses E. L. Bean, A. Hirsch H. F. Clark, H. E. Stokinger W. E. Towell, C. M. Tarzwell J. R. Harlan		
	QUALITY, NEEDS, AND EFFECTS OF AGRICULTURAL USERS: 11:15 - 1:45		J. W. Mandia (Moderator)
11:15 - 11:35	Quality Criteria for Irrigation	18	L. V. Wilcox
11:35 - 11:55	Economics of Agricultural Use	19	A. R. Blanch
11:55 - 12:15	Effects of Irrigation Return Flows	20	C. G. Gunnerson
12:15 - 1:00	Lunch		
1:00 - 1:45	Panel Discussion: Quality, Needs, and Effects of Agricultural Users A. R. Blanch, R. D. Hill C. G. Gunnerson, L. V. Wilcox		
	WATER QUALITY MANAGEMENT ROLE OF INDUSTRIAL USERS: 1:45 - 4:30		H. H. Black (Moderator)
	The Challenge, the Issues, the Problems	21	T. Powers

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Tuesday, March 2			
	How Industries, Organize and Operate to Manage Water Quality		
	The Pulp, Paper and Paperboard Industry	22	F. T. Shepherd
	The Oil Refining Industry	22	H. F. Elkin
	The Chemical & Petrochemical Industry	22	E. J. Fox
	The Iron and Steel Industry	22	G. A. Pettit
3:30 - 4:30	Panel Discussion: Water Quality Management Role of Industrial Users F. T. Shepherd H. F. Elkin E. J. Fox G. A. Pettit		
Wednesday, March 3			
	MAN INFLUENCES WATER QUALITY - DIRECT WASTE DISCHARGES: 8:30 - 11:15		P. F. Atkins (Moderator)
8:30 - 9:00	Effect of Wastewater Discharges (Treated, Untreated, Natural Pollution) on Aquatic Environment	23	H. W. Jackson
9:00 - 9:30	Land Runoff and How It Influences Water Quality	24	S. R. Weibel
9:30 - 10:00	Bacteriological Considerations of Wastewater Discharges	25	H. L. Jeter
10:00 - 10:30	Biological Treatment Technology and Its Impact on Water Quality	26	F. J. Ludzack
10:45 - 11:15	Panel Discussion: Influence of Direct Waste Discharges on Water Quality H. W. Jackson F. J. Ludzack H. L. Jeter S. R. Weibel		
	MAN'S INFLUENCE ON WATER QUALITY THROUGH IMPOUNDMENTS: 11:15 - 1:45		J. M. Symons (Moderator)
11:15 - 11:30	Overall Picture of Impoundment Problems	27	J. M. Symons
11:30 - 11:45	The Significance of Eutrophication	28	J. K. Neel
11:45 - 12:00	Practical Implications of Current Impoundment Work for Future Comprehensive Management	29	J. E. McLean
12:00 - 12:15	Water Quality in Impoundments - Experiences of T. V. A.	30	M. A. Churchill
12:15 - 1:00	Lunch		

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Wednesday, March 3			
1:00 - 1:45	Panel Discussion: Man's Influence on Water Quality Through Impoundments M.A. Churchill J.E. McLean J. K. Neel		
	BIOCIDES (PESTICIDES) IN THE ENVIRONMENT: 1:45 - 4:45		H. F. Kraybill (Moderator)
1:45 - 2:15	Potential Long Term Health Impact of Pesticides in the Environment	31	H. F. Kraybill
2:15 - 2:45	Analytical Chemistry of Pesticides in Water	32	A.A. Rosen
3:00 - 3:30	Sampling of Aquatic Environment for Pesticide Pollution	33	J.B. Anderson
3:30 - 4:00	Pesticides in Aquatic Ecology	34	D.I. Mount
4:00 - 4:45	Panel Discussion: Biocides (Pesticides) in the Environment J.B. Anderson D.I. Mount J.M. Cohen G.G. Robeck M.B. Ettinger A.A. Rosen R. Smith		
5:30 - 6:30	Pre-Prandials and Social Hour at Four Seasons Marina, 4809 Kellogg Avenue		
6:30 - 7:30	Course Banquet		
7:30	Speaker "Developments in Public Health Service Environmental Health Programs" Robert J. Anderson, M.D. Assistant Surgeon General Chief, Bureau of State Services Public Health Service Washington, D.C.		R. J. Anderson
Thursday, March 4			
	RECENT DEVELOPMENTS IN WATER AND WASTEWATER TREATMENT TECHNOLOGY: 8:30 -12:30		
8:30 - 9:10	The Problem of Synthetic Organic Wastes	35	B.A. Punghorst
9:10 - 9:50	Susceptibility of Viruses in Treatment Technology	36	G. Berg
10:00 - 10:40	Advances in Coagulation Treatment Technology	37	S.A. Hannah
10:40 - 11:30	Applied Engineering Research in Removal of Viruses and Persistent - Organic Chemicals Including Detergents, Pesticides, and Others	38	G.G. Robeck

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Thursday, March 4			
11:40 - 12:30	Advanced Waste Treatment Technology	39	F. M. Middleton
12:30 - 1:15	Lunch		
1:15 - 2:00	Waterway Wildlife - Film		K. H. Maslowski
	MAN - WATER - AIR: 2:00 - 4:30		H. P. Kramer (Moderator)
2:00 - 2:40	Man - An Ecological Factor in the Environment	40	B. B. Berger
2:40 - 3:20	Air and Water - Dependent or Independent?	41	V. G. MacKenzie
3:40 - 4:30	Panel Discussion: Man - Water - Air B. B. Berger V. G. McKenzie		
4:30 - 4:45	A. Class Assignment for Case Study B. Introduction to Brief Managerial Experience Reports from Group Leaders		Staff
Friday, March 5			
8:20 - 8:30	Quiz on Assigned Case Study Reading		
	ESTUARY PROBLEMS IN WATER QUALITY MANAGEMENT: 8:30 - 12:00		B. H. Ketchum (Moderator)
8:30 - 9:00	Introduction to Marine Waters - Known and Unknown	42	B. H. Ketchum
9:00 - 9:30	General Concepts of Estuarine Problems	43	D. J. O'Connor
9:30 - 10:00	Specific Application of Analyses to the Estuarine Environment	44	R. V. Thomann
10:00 - 10:30	Administrative Considerations in Estuarine Analysis	45	J. Harrison
10:50 - 12:00	Panel Discussion: Estuary Problems in Water Quality Management P. DeFalco J. Harrison D. J. O'Connor R. V. Thomann		
12:00 - 1:00	Lunch		
	RESEARCH PROBLEMS: 1:00 - 4:30		L. W. Weinberger (Moderator)
1:00 - 1:30	Research - The Problem and the Future	46	L. W. Weinberger
1:30 - 2:00	Research Activities at SEC - Present and Future	47	P. W. Kabler
2:00 - 2:15	Need for Basic Engineering Research	48	G. G. Robeck
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2:30 - 3:00	Technical Aspects and Importance of Biodegradability	50	M. B. Ettinger

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3:45 - 4:30	Panel Discussion: Research Problems M. B. Ettinger F. M. Middleton P. W. Kabler G. G. Robeck D. W. Ryckman		
Monday, March 8			
8:30 - 9:30	Managerial Experiences from Groups A & B (Two Reports Per Group)		
	PUBLIC RELATIONS IN WATER QUALITY MANAGEMENT: 9:45 -12:15		P. W. Weiser (Moderator)
9:45 - 10:00	The Future in Wastewater Programs	52	A. D. Caster
10:00 - 10:20	Improving Managerial Skills in Public Relations	53	S. Baxter
10:20 - 10:40	Role of Public Information in Water Quality Management	54	R. S. Hutchings
10:40 - 11:00	Professional Training to Meet Ever Changing Public Demands	55	J. P. Sheehy
11:00 - 12:15	Panel Discussion: Public Relations in Water Quality Management S. Baxter J. P. Sheehy R. Hutchings A. D. Caster		
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	COMMUNICATION IN WATER QUALITY MANAGEMENT: 1:00 - 3:30		W. L. Stucker (Moderator)
1:00 - 1:40	Dissemination of Technical Material to the Public	56	M. M. Myers
1:40 - 2:30	Interpersonal Communications	57	G. D. Thomas
2:45 - 3:30	Panel Discussion: Communication in Water Quality Management G. D. Thomas M. M. Myers		
3:30 - 4:45	Introduction to Specific Case Study Involving Enforcement and Technical Services Aspects - Discussion -	58	Staff F. W. Kittrell E. C. Tsivoglou
Tuesday, March 9			
8:30 - 12:20	Case Study Session Groups A & B: Enforcement - A. W. West, R. K. Ballentine, D. G. Ballinger K. M. Mackenthun		

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Tuesday, March 9			
	Groups C & D: Technical Services - E. C. Tsivoglou, S. D. Shearer, J. B. Anderson, C. E. Sponagle		
12:20 - 1:30	Lunch and Travel from TA & I Office to the Public Health Service Water Pollution Surveillance System		
	WATER POLLUTION SURVEILLANCE: 1:30 - 3:45		
1:30 - 2:10	Introduction to Water Pollution Surveillance	59	L. Weaver
2:10 - 2:35	Examples of Unusual Data and Its Use	60	R. C. Kroner
2:35 - 3:45	Orientation: Visits in Four Groups to Spectrograph, Radiological, Biology and Organic Laboratory Sessions		R. C. Kroner Staff
3:45 - 4:45	Managerial Experience from Groups C & D		
Wednesday, March 10			
8:30 - 9:10	THE EXPERT'S RESPONSIBILITY IN PUBLIC AFFAIRS	62	E. F. Cook
	THE ROLE OF GOVERNMENTAL AGENCIES IN WATER QUALITY MANAGEMENT 9:10 - 12:15		J. H. Svore (Moderator)
9:10 - 9:30	A State Program for Water Quality Management	61	C. L. Summers
9:30 - 9:45	Federal and State Partnership in Basin Development	63	H. A. Howlett
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10:15 - 10:30	The Role of the Department of the Interior in Inter-Agency Planning and Programming	66	H. P. Caulfield
10:30 - 10:45	The Role of the Department of Health, Education and Welfare (Public Health Service) in Inter-Agency Planning and Programming	67	K. S. Krause
11:00 - 12:15	Panel Discussion: Inter-Agency Relationships and Cooperation H. P. Caulfield, H. R. Williams H. A. Howlett, E. Weber K. S. Krause, C. L. Summers		
12:15 - 1:00	Lunch		

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1:30 - 2:00	Economic Considerations in Water Quality Management	69	A. Kneese
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2:45 - 3:30	Promoting a Successful Bond Issue "Getting Sewer Programs Off the Ground"	70	P. Merrill
3:45 - 4:30	Construction and Operating Cost for Waste Treatment Plants	71	P. W. Reed
4:30 - 5:00	Case Study Review Group		
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8:15 - 9:00	Public Health Service Water Pollution Control Field Laboratories	72	D. H. Howells
	LEGAL ASPECTS OF WATER QUALITY MANAGEMENT: 9:00 - 12:15		H. H. Rogers (Moderator)
9:00 - 9:30	Implementing Enforcement Actions at the PHS Regional Level		H. H. Rogers
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10:45 - 11:15	Compacts and Water Resources	77	M. Wendell
11:15 - 12:00	General Discussion - Panel		
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1:00 - 4:30	Case Study Reports		Staff
4:30 - 4:45	Course Critique Assignment		
Friday, March 12			
	COMPUTERS IN WATER QUALITY MANAGEMENT: 8:30 - 11:15		
8:30 - 9:20	Storage and Retrieval of Basic Data for Water Quality Control "STORET"	78	D. P. Dubois
9:20 - 10:00	Calculator or Computer - Management's Consideration in Data Processing	79	E. A. Diephaus
10:10 - 10:50	Application of Systems Analysis	80	J. F. Santner
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12:00 - 12:15	Adjournment		
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1:30 - 4:30	Optional		
	1 Tour of SEC Facilities		
	2 Consultations with SEC Personnel through prior arrangements		

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BASIN PROGRAMMING CONCEPTS

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A Perspective on Water Pollution Control Administration

A Current Basin Study

State Role in Basin Programming

Corps of Engineers' Role in Basin Programming

MAJOR ISSUES IN BASIN PLANNING

I HOW CLEAN SHALL WATER BE?

Consider from the viewpoint of national objectives for the individual purpose water serves:

A Public Water Supply

B Propogation of Fish and Aquatic Life

C Recreational Purposes

D Agricultural Purposes

E Industrial Purposes

Consider from the viewpoint of:

A Modern Urbanization

B Conservation

C The Environment

Consider from the viewpoint of national policies and/or policy statements

A The Presidency

B The Congress

C The Administrative

D The National Academy of Sciences

Consider from the viewpoint of controlling factors: e.g.:

A Waste Treatment Technology

B Science and Water Quality Standards

C Detergents

D Virus

II THE NATURE, EXTENT AND EFFECTIVENESS OF COMPREHENSIVE PLANNING FOR WATER POLLUTION CONTROL

Consider from the viewpoint of:

A "Comprehensiveness"

B Economics

C Related Land Planning

D Planning and Program Operations

E Plan Implementation

III THE ROLE OF RESEARCH

Consider from the viewpoint of:

A Engineering Innovation and Technology

B The Research Budget

C R & D and American Industry

This outline was prepared for the Training Program by Professor Leonard B. Dworsky, Director, Cornell University, Water Resources Center, Ithaca, New York

PUBLIC HEALTH SERVICE ROLE IN BASIN PROGRAMMING

Your presence here today indicates your awareness of the water resources problems the nation now faces. It also gives evidence of your interest in work underway having as its goal the solution of these problems. Since water pollution is a major cause of an impending water shortage, I am pleased to have this opportunity to talk with you about a program of the Public Health Service having as its goal the removal of this cause. I refer, of course, to the Comprehensive Water Pollution Control Programs.

Of the nineteen such projects now planned for the entire country, eight are currently underway. We will undertake the remaining eleven as rapidly as possible, basing priority on the urgency of the water pollution control needs within the respective basins.

A comprehensive water pollution control program is a systematic implementation of means and measures for controlling pollution and preventing pollutants from interfering with legitimate water uses throughout a region or river basin. The program plan provides guidelines for all interests--Federal, state, and local--for meeting water quality goals which will permit all legitimate water uses.

So much for a definition but what does it really mean? What comprises a comprehensive water pollution control program? Who will be involved? A plan of action will be the major product of the intensive preliminary study. Who will implement and administer it? Let us consider these questions in order and find the answers.

In the broadest of terms a study leading to a program may be divided into two parts - a determination of needs and of methods to meet these needs. Of equal importance is the development of an authority to implement and administer the program once the plan has been developed.

Taking first things first, what are our needs? For what uses is water quality to be protected? The list is long, ranging from domestic water supplies to stream assimilation and transport of waste discharges. It includes water for out-of-stream uses for domestic, industrial, and agricultural purposes. In-stream uses may include swimming, water skiing, boating, and fishing. Esthetic considerations are part of the picture, too; certainly the beauty of a clean stream is desirable and to be protected.

An inevitable result of our very existence is the generation of wastes. Since we cannot yet provide one hundred percent treatment of wastes at prices we can afford, disposal of the residue is generally to the nearest water body. The use of streams and rivers for the assimilation and transport of treated wastes in a manner that will not cause pollution is perfectly legitimate and takes its rightful place in the complete catalogue of water uses. Whether the uses are completely catalogued for a given study area can only be determined from discussions with those living and working in the area - they must be given every opportunity to make their wishes and needs known.

Having identified the water uses it is desirable to protect or restore, the list may disclose some that cannot now be realized and others that will be jeopardized or eliminated in the future as the result of water pollution. In other words, it may be found that existing pollution, either natural or manmade, already degrades water quality so that it is partially or wholly unsuitable for some desired uses. Looking into the future, it may become evident that wastes from projected population, industrial or agricultural growth will damage water quality to the extent that many uses will be impaired or completely prevented.

Each use listed has a companion quality of water that varies with the need. For example, users of water for domestic purposes prefer a clear, tasteless, colorless, odorless, and bacteriologically safe water. Other preferred characteristics are low total dissolved solids, low hardness, low chlorides, etc. Industry is also interested in water of like quality especially in food processing. For cooling purposes, water of a lower quality is acceptable. Recreationists' quality desires, insofar as water contact sports are concerned, equal those of domestic users with regard to color, absence of solids and any materials in toxic and/or irritating concentrations; and they prefer water of even higher bacteriological quality than do domestic users. Fishermen insist on water quality which will maintain a healthy, abundant game fish population and are rightly concerned with the maintenance in streams and lakes of adequate concentrations of dissolved oxygen, favorable temperatures, and the absence of materials in toxic concentrations. Certainly all living on the banks of or near lakes, streams, and rivers want and have a right to water characteristics that do not offend - the absence of odors, low color, low turbidity, and no oils and greases, to name a few.

Even dischargers of wastes -- many times unwittingly -- have water quality requirements. They want receiving waters of adequate quality to assimilate the wastes for which they must provide disposal without creating problems for themselves or their downstream neighbors. This means a stream with an abundance of dissolved oxygen if the wastes are organic in nature, a low temperature if the wastes are hot, a minimum or absence of color if wastes are colored, and so on. And so it goes-each use or user of water has preferred quality characteristics.

Again, a complete list specific to a given study area can be compiled only with the advice and guidance of those in the area - the water users and the waste disposers. A comprehensive water pollution control program can be successful only to the extent that those who use or want to use the waters of the basin under study want it to be.

Having determined water quality goals for the spectrum of present or anticipated uses, the next step must pinpoint the causes which are now preventing or will at some time in the future prevent these goals from being attained. Turning back to our list of uses, does the discharge of untreated sewage within the study basin make water bacteriologically unsafe for domestic use? Do industrial waste discharges cause tastes and odors or introduce materials in toxic concentrations? Do agricultural activities result in runoff carrying excessive concentrations of pesticides or plant nutrients into streams serving as sources of raw water for domestic use? Are fish killed as a result of this drainage? Do natural sources such as salt springs or dense swamps diminish the suitability of water for use? Such questions must be answered. To do so calls for locating and measuring both the quantity and quality of all wastes whose discharge results in pollution. Only when this is done will it be possible to consider in a meaningful way what steps can be taken to eliminate or control the discharge of pollutants so that some, if not all, quality goals can be reached.

For example, if untreated sewage discharges cause bacteriological problems, a logical step would be to provide treatment including disinfection. If industrial wastes cause tastes or odors, treatment again is indicated. When, even after adequate treatment, residual wastes still exceed the assimilative capacity of receiving streams, the Federal Water Pollution Control Act makes possible the provision of storage for the regulation of streamflow for the purpose of water quality control.

In some areas of the country municipal sewage can be treated by today's techniques to ensure a 90-95% reduction of its biochemical oxygen demand. Further, it can be disinfected until it is bacteriologically safe; but in many instances the remaining phosphates and nitrates still pose a serious water pollution problem. Their removal has yet to be accomplished at costs considered economically feasible. And, as long as these nutrients are present in sewage effluents, or other waste discharges, the spectre of gross algal blooms with their attendant taste and odor problems will confront us.

Having considered pollution control of capturable wastes, what about those that are not so readily collected and conveyed to treatment facilities. As we learn more and more about surface runoff from urban and agricultural areas, the more we realize that even one hundred percent reduction of the biochemical oxygen demand of municipal and/or industrial wastes may not be enough. Indeed, the greatest problem may not result from the organic content of wastes at all but from some other characteristic. Surface runoff-stormwater-has been found to contain substantial loads of oxygen demanding materials while drainage from agricultural lands may carry with it excessive concentrations of bacteria, organic material, and the now widely publicized pesticides. It might be noted in passing that agricultural runoff also contains nutrients that cause microscopic as well as macroscopic plants to grow and thrive. A comprehensive water pollution control program must cope with all these - identifying and quantifying pollutants and sources and developing methods and means for their elimination or control.

When the quality of water is degraded to the extent that it is undesirable for use, treatment must be provided, a new source of water sought, or provisions made for flow regulation. All have their price tags. And so do all aspects of water pollution control.

Which brings us to another phase of a comprehensive water pollution control program. Having identified and catalogued the desires of water users and wastes disposers, discussed and agreed on quality goals, identified waste components and characteristics, if any, that make these quality objectives or needs unattainable, and investigated ways, methods, and measures for minimizing or eliminating pollution, we must next consider costs.

Costs of treatment, complete or partial; costs of streamflow regulation; costs of waste storage, of waste diversions, of new sources of water to replace those no longer suitable; or the costs of doing nothing. Which combination of these available steps will bring us closest to all our water use goals at costs we are willing to pay?

Twenty or even fewer years ago this problem would have been solvable only after lengthy, time consuming calculations due to its complexity and the abundance of unknowns. Today, although still faced with the unknowns, we are aided by electronic computers into which are fed data on existing water quality, desired water quality, and the costs of quality modification by various methods and means. With proper programming, only a few minutes are required to ascertain what can be done at what costs to achieve desired goals. A pipe dream? No, an actual fact in at least one of the PHS projects, the Delaware River Estuary Study; a goal in all our comprehensive water pollution control programs.

This computer program or model will be a working tool for the water pollution control basin authority. As information is fed into the computer on streamflow and quality, waste flows and their quality, and anticipated weather conditions, the model will advise the control authority what can be done under each set of conditions or situations to achieve or maintain the water quality goals. It will indicate the costs of various alternatives, including the costs of attaining something less than the desired quality. For example, an industry whose wastes have a particularly heavy impact on water quality may be required to reduce its waste discharges for a given period. Or temporary additional waste treatment may be stipulated.

If streamflow regulation is a factor, information will be obtained from the Weather Bureau on rainfall and streamflows to be expected. Releases from Federal reservoirs in which storage for streamflow regulation for water quality control purposes has been provided can then be scheduled to arrive at the critical reach of the stream at the proper time and in the right amount. This is efficient use of the water resource.

Obviously the success of this approach depends on the validity and accuracy of the data fed into the computer. Here the complete cooperation of all basin interests is vital. Industry must be able and willing to provide information on the quality and quantity of its wastes, and methods and costs of treatment or control. Equally important, there must be a realistic understanding of industry's water quality requirements. Cooperation of Federal agencies is vital -- stream monitoring must provide a continuing flow of quality data to headquarters; reservoir releases must be regulated to maintain necessary streamflows; and forecasting of rainfall, runoff, and streamflows will be an important link in the chain.

Competing interests must realize that the achievement of quality that will permit all uses may not always be economically feasible. Under such conditions compromises must be made to achieve the greatest good at the least cost. Earlier, I intentionally used the term "preferred uses" - with all things equal, we would prefer to have water of such quality that there will be no restraint on any use. Unfortunately, we will seldom be able to pay for this - choices must be made and a computer program will provide the information from which the most effective, least painful choice can be identified.

By this time you have the idea that a comprehensive water pollution control program must go far beyond a basin study and the preparation and issuance of a report. The study must provide the basis for action and some group must be empowered to act. Its name is not important - call it an authority if you will, or a voluntary basin or regional committee or board, -- but its make-up and role are paramount. It must understand and represent the joint interests of all water users in the basin and have the power to act or require action to achieve desired goals. Conceivably it would include representations of municipal and industrial interests, spokesmen for recreation and navigation and those who have agricultural needs in mind. Certainly the Federal government should be represented.

Responsibility for the formation of such an authority lies in the state or states comprising the study area. If the Federal government makes contributions in the form of impoundments providing storage for water supply or water quality control or in any other manner, representation on such a group and participation in its activities is desirable.

A Comprehensive Water Pollution Control Program is not a project solely of the Public Health Service. To so identify it would violate the interest and spirit of the Water Pollution Control Act which, in part, says:

> "The Secretary shall, after careful investigation, in cooperation with other Federal agencies, with State water pollution control agencies and interstate agencies, and with municipalities and industries resolved, prepare or develop comprehensive programs. . . "

Congress has assigned to the Secretary of the Department of Health, Education, and Welfare, the responsibility of administering the Water Pollution Control Act and the Secretary has delegated to the Public Health Service this responsibility. As Congress appropriates funds for the development of a comprehensive program, the Public Health Service does not consider that it has the authority to develop a program to meet only its own standards. This would be the easy way. Instead, our objective is to develop a program that will effectively control water pollution in consonance with all the water use interests in the entire basin. Appropriate assistance and services will be sought and paid for and advice and guidance from people of the basin will be welcome.

This outline was prepared for the Training Program by Robert W. Haywood, Jr., Chief, Review and Evaluation Unit, Water Projects Section, Technical Services Branch, Division of Water Supply and Pollution Control, Public Health Service, Department of Health, Education and Welfare, Washington, D. C.

Outline Number

INCREASING IMPORTANCE OF GROUND WATER

Increasing Role of Ground Water 6

A Long Range View on Ground Water Potential and Development in River Basin Planning 7

Natural Occurring Water Quality Problems

Ground Water Protection During Wastewater Application 9

A State Program for Ground Water Protection

INCREASING ROLE OF GROUND WATER

I INTRODUCTION

A Continued increase in water demands require full development of all water resources.

  1 Need for adequate information on geologic and hydraulic character, and chemical quality of aquifers.

II IMPORTANCE OF GROUND-WATER SUPPLIES

A Large quantities used for agriculture in west and southwest United States.

B Often sole source of dependable water supplies.

C Dependence of many small communities on ground water supplies.

D Additional large quantities can be developed in many areas.

III SOME FACTORS LIMITING AMOUNTS OF GROUND WATER AVAILABLE FOR FUTURE DEMANDS

A Overdevelopment, Waste, and Pollution

B Lack of Local Legislation and Enforcement.

IV SOME PROBLEMS RESULTING FROM INTER-CONNECTION BETWEEN SURFACE WATER AND GROUND WATER

A Interception of Stream Flows By Well Withdrawals.

B Damage From Rising Water Tables Resulting From Poor Soil Drainage and Over-Application of Surface Water.

  1 Sub-irrigation in some agricultural areas in the west.

  2 Building foundations and sewer lines.

V GROUND-WATER LEGISLATION

A Many states attempting to apply historical concepts of surface water rights in formulating ground-water rights.

  1 Could limit full development in some areas.

VI CURRENT STUDY OF GROUND WATER IN THE SOUTH PLATTE RIVER BASIN

A Close Relation Between Surface Water and Shallow Ground Water

  1 Diversions of river flow are principal source of recharge.

  2 Aquifer contributes large amounts to river flow as ground-water return flow.

  3 Chemical quality of ground-water affected by quality of recharge water from streams. Similarly, quality of surface water affected by ground-water return flow.

B Large Quantities Used For Irrigation and Public Supplies

C Shallow Aquifer Very Susceptible to Pollution and Contamination

1 Contamination incident in vicinity of Rocky Mountain Arsenal.

2 Occurrence of nitrate, ABS, and bacteria in aquifer.

3 Future source of potable water limited by present pollution.

This outline was prepared for the Training Program by Lester M. Klashman, Regional Program Director, Division of Water Supply and Pollution Control, Public Health Service, 621 - 17th Street, Denver, Colorado.

A LONG RANGE VIEW ON GROUND-WATER POTENTIAL AND DEVELOPMENT IN RIVER BASIN PLANNING

I THE RIVER BASIN AS AN AREAL UNIT FOR THE STUDY OF GROUND WATER

Because the movement of ground water is controlled by the same forces that move surface water, namely differences in head, the gains or losses of ground water from any large basin are considered insignificant in relation to the total volume of water within the basin. Hence, the surface drainage area (basin) provides a logical study unit for ground-water as well as surface-water resources (especially in humid areas where the dry-weather flow of streams consists appreciably of discharging ground water).

II THE DESIRABILITY OF REGIONAL VERSUS LOCAL DEVELOPMENT OF GROUND-WATER RESOURCES

Traditionally, ground water has been developed only at points of need, leaving most of the resources of most eastern basins relatively untapped. The subsurface storage potential of important aquifers in many eastern basins greatly exceeds that of surface reservoirs indicating great potential for exploitation of this natural storage capacity. Regional development of ground water may in the future provide water for intrabasin transfer for purposes such as low-flow augmentation, reservoir replenishment, and recharge to stream-side aquifers.

III THE IMPACT ON THE HYDROGEOLOGIC REGIMEN CAUSED BY SURFACE-WATER DEVELOPMENT

The effects of some surface-water developments on subsurface hydrologic conditions are obvious, such as the raising of ground-water levels by dam construction or the increased discharge from an aquifer to a surface source caused by the lowering of surface stages. A sound management program should consider ways to manipulate the hydrologic regimen in order to gain certain advantages. For example, in some localities it may be possible to obtain irrigation water from aquifers some distance removed from streams during dry-weather periods without diminishing the flow of the stream until recharge conditions again prevail.

Throughout the Great Lakes drainage basin and the northern portions of the Ohio River Basin, most major stream valleys contain great accumulations of permeable sediments that may yield tremendous quantities of water without undue drawdown because of the proximity of perennial streams to replenish the sediments. Such potential has been exploited only to a very minor degree.

IV GEOCHEMICAL STUDIES AS A SOURCE OF BASIN INFORMATION IN WATER-QUALITY CONTROL PROGRAMS

The geochemical regimen in any basin is the most important natural control on water chemistry because the aquifers of the basin impart the general mineral characteristics to the water and because critical quality problems generally occur during low-flow periods when the streams contain maximum admixtures of ground water. Limitations on use due to excess mineral concentrations are imposed by the geochemical characteristics of aquifer materials. Because mineral concentrations of surface water tend to decline as runoff increases, ground-water quality data provide a basis for predicting periods of maximum mineral concentrations and (or) determining feasibility of remedial actions.

V REFERENCES

In preparation stage, not as yet published.

A A Water Atlas of the Maumee River Basin - Ohio, Indiana, Michigan, in preparation as U. S. Geological Survey Hydrologic Atlas (or Water-Supply Paper).

B Ground-Water Distribution and Potential in the Scioto, Wabash, Kanawha, Monongahela, and Allegheny Basins, Interim Reports 1, 2, 3, 4, and 5, respectively, Corps of Engineers, Ohio River Basin Comprehensive Plan, Hydrology Appendix in preparation by U. S. Geological Survey.

This outline was prepared for the Training Program by Morris Deutsch, Chief Midcontinent Area Project Office, U. S. Department of Interior, Gahanna, Ohio

GROUND WATER PROTECTION DURING WASTE WATER APPLICATION

I INTRODUCTION

Utilization of the soil and subsurface formations for treating, containing, disposing of, or reclaiming and storing water from liquid wastes may be looked on as a surface water pollution control technique. It is a means for keeping wastes out of surface waters and thus reducing potential surface water pollutional loads. However, soil and subsurface applications of waste, to be useful, must be handled in such a way that the pollution problem is not just shifted from the surface waters to the ground waters.

II HISTORICAL USE OF GROUND AND SUBSURFACE FOR WASTE DISPOSAL

A Out of Sight - Out of Mind Disposal Approach

In many cases soil disposal has been used because it was either the most convenient or it was the method of last resort.

1 Individual or lot disposal - convenient for developers in lieu of alternatives.

2 Industrial waste disposal - convenient and economic for seasonal situations.

B Irrigation Application

1 A "natural" in water short areas.

C Ground Water Recharge

1 More recent interest in treated wastes for recharge purposes.

D Combination of success and failure has demonstrated that soil methods can be useful but that a greater knowledge is needed before proper design and operating criteria can be proposed for many situations.

III SOIL AND SUBSURFACE WASTE APPLICATION METHODS AND SOME AREAS OF THEIR USE

A Surface Application

1 Basin or flooding

Industry, Community, Recharge

2 Furrows or ditches

In combination with irrigation use and and/or recharge

3 Spray - runoff

Seasonal and/or limited volume wastes

B Shallow Sursurface

1 Trenches, pits, or beds - on lot disposal

2 Shafts or wells - recharge

C Deep-Well Injection

1 For confinement of relatively small volumes of "untreatable" wastes.

IV CURRENT INVESTIGATIONS

A Factors Influencing "Treatment"

1 Pilot lysimeter studies

Soil, site, load, and method of application factors

2 Field studies

Napoleon, Ohio - spray application

Westby, Wisconsin - ridge & furrow application

Long Island, New York - subsurface application

B Factors Influencing "Acceptance"

1 Location of clogging

2 Possible contributors to clogging

3 Interrelationship of "treatment" and "acceptance"

C Deep-Well Disposal

1 Define importance of reactions between pore water and injected wastes and establish criteria for predicting and testing their compatability.

This outline was prepared for the Training Program by Thomas W. Bendixen, Soil Scientist, Engineering Section, Basic & Applied Sciences Branch, Water Supply & Pollution Control, SEC.

A STATE PROGRAM FOR GROUND WATER PROTECTION

I OBJECTIVES OF PROGRAM IN PENNSYLVANIA

Develop programs to prevent and/or abate ground water pollution. In order to implement these programs it is necessary to evaluate and appraise the occurrence and quality of ground water in the state, appraise areas of actual or potential ground water pollution, recognize causes of ground water pollution in the state, train regional personnel in ground water geology and ground water pollution, and encourage ground water pollution research.

II RESPONSIBILITY FOR STATE PROGRAM

A Clean Streams Act 1937

> "An act to preserve and improve the purity of the waters of the Commonwealth".
>
> "Waters of the Commonwealth shall be construed to include any and all rivers, streams . . . and all other surface and underground water. . . "

III GROUND WATER IN PENNSYLVANIA

A Pennsylvania Geologic Survey

B Pennsylvania Department of Health

- 1 Data collection
- 2 Date analysis
    - a Ground water occurrence
    - b Ground water quality
    - c Potential areas of ground water pollution

IV TRAINING OF FIELD PERSONNEL

A Ground Water Hydrology

B Geology

C Ground Water Pollution

V CAUSES OF GROUND WATER POLLUTION IN PENNSYLVANIA

A Sewage

B Industrial Waste

C Acid Mine Drainage

VI GROUND WATER POLLUTION RESEARCH

A Movement and Renovation of Wastes Through Soil and Rock

- 1 Penn State University
- 2 Drexel

B Acid Mine Drainage

This outline was prepared for the Training Program by Grover H. Emrich, Ph. D., Ground Water Geologist, Stream Quality Section, Department of Health, Harrisburg, Pennsylvania.

Outline Number

QUALITY CRITERIA FOR DOMESTIC, RECREATIONAL AND AQUATIC LIFE USES

Water Quality Criteria 11

Basis for Microbiological Criteria 12

Criteria for Water in Aquatic Life Use

Ultimate Goals in Public Water Supply - Chemical Criteria 14

Water Quality for Recreation 15

Conservationists' Views of Water Quality Management 16

Toxicologic Perspective on the Total Impact of Chemical Environmental Pollutants on Human Health

WATER QUALITY CRITERIA

I INTRODUCTION

A Needs

B Definition of Terms

II WATER QUALITY CONTROL

A Objectives

B Practice

C Criteria

III DRINKING WATER QUALITY

A Quality Objectives

B Criteria Vs. Knowledge

C Standards

IV POLLUTION CONTROL REQUIREMENTS

A State Regulations

B Standards Vs. Needs

V WATER QUALITY OBJECTIVES BY USE

A Descriptions of Wants and Don't Wants

VI WATER QUALITY GUIDES

A Pollutants Concentrations Vs. Effects

B Use-Concentration Spectra

C Limiting Concentrations Tabulations

VII WATER QUALITY GOALS

A How Do We Set Them

This outline was prepared for the Training Program by George W. Burke, Jr., Chief Water Quality Criteria and Practice Section, Technical Services Branch, Division of Water Supply and Pollution Control, Washington, D.C.

BASIS FOR MICROBIOLOGICAL CRITERIA

I MICROBIOLOGICAL CRITERION

The microbiological criterion is a standard of judging through the application of appropriate test procedures by which facts, principles and opinions are combined in forming the correct evaluation respecting the quality of water for any specific use or uses.

II CRITERIA

The bacteriological criteria are dependent on:

A Objective for making the judgement which is determined by the proposed water use;

B Methodology chosen for the investigation;

C Standardized techniques in test procedures;

D Frequency of examinations;

E Choice of sample locations; and,

F Detailed analysis of data.

These six items are essential in the application of microbiological criteria to waters.

III OBJECTIVES IN WATER CRITERIA

The basic objective in the bacteriological examination of waters is the determination of the recent and/or more remote environmental contacts of the water which may influence its use for any purpose.

These objectives are subdivided in:

A Potable Water

1 Treated waters as a control on the effectiveness and safety of the treatment process which can produce a product free from any type of coliform microorganism and a very low total bacterial count.

2 Untreated water as a procedure to determine its natural purity, safety or use for drinking and culinary uses by proof of freedom from any hazard (contact with any sources which may yield pathogenic entities to the water).

B Non-potable water in which judgement is made for:

1 Recreational use of various types;

2 Irrigation or processing uses;

3 Comparative pollution existing in two or more sources of supply;

4 Evaluation of pollution control procedures; and,

5 Tracing or evaluation of sources of pollution.

IV METHODOLOGY

This includes the choice of the bacterial group or species used as the measure of water criteria and the detection procedures used to quantitatively measure the microorganism(s).

V TECHNIQUE

Technique includes the skill and standardization of procedures used in the actual examination of each sample. Careless or inept laboratory work invalidates the application of any water criterion.

VI Frequency and choice of samples are an intergraded portion of the bacteriological quality evaluation of the water and are, therefore, an essential portion to be considered in the establishment of water criteria. These vary with the individual problem under investigation.

VII ANALYSIS OF DATA

The analysis of data is the organization of the individual results in order to determine compliance with the established standard or criterion.

VIII THEORY OF BACTERIA INDICATORS

A The routine detection of the pathogenic entities in water is not practical as a procedure for establishing the water as being free from hazard. Quantitative procedures are inadequate and the procedures fail to indicate the appearance of potential danger such as traces of sewage pollution.

B Certain bacterial groups or species which are characteristic of the gut of warm-blooded animals are substituted for the pathogenic microorganisms, as for example, the coliform group.

C The presence of the indicator microorganisms is interpreted to demonstrate the water has come in contact with an environment which may harbor pathogenic entities and constitutes as hazard to health (it may at any time contain pathogenic entities).

D The density of indicator microorganisms in the mixed excreta from a number of individuals or in sewage will far out number the pathogenic microorganisms, thus permitting detection of the indicators in much smaller samples of water. This serves as a warning of potential danger or hazard.

IX THE COLIFORM GROUP

Members of the coliform group have been used since 1880 as a measure of pollution in water. This group has the following attributes as an indicator of pollution:

A Members of the coliform group are reported in large numbers in the guts and fecal excreta of animals (human, animals and birds).

B Waterborne diseases may be spread by or associated with feces and sewage.

C Increasing densities of the coliform group indicate the increasing quantity of pollution.

D Destruction of the coliform group by treatment procedures or natural purification indicates the absence of enteric pathogenic bacteria, although it is possible viruses may be an exception to this assumption.

E Absence of members of the coliform group in a natural (untreated) water would indicate the water had not come in contact with the normal environmental sources of the enteric pathogenic entities (or with fecal or sewage pollution).

X INTERPRETATION OF THE COLIFORM GROUP

A Presence of the coliform group indicates pollution of the water has occurred.

B Increasing numbers indicates increasing pollution.

C Treated or potable waters containing coliform bacteria demonstrates inadequate treatment or natural purification.

D Any member of the coliform group in a potable water without regard to source should be considered of more or less sanitary significance.

E All members of the coliform group are to be considered of possible fecal origin in the absence of absolute proof to the contrary.

F Waters containing members of the coliform group due to fecal or sewage pollution may contain pathogenic entities on an intermittant or continuous basis, depending on the sources of the sewage.

XI FECAL COLIFORM GROUP

The fecal coliform group is that portion of the coliform group which have their native habitat in the gut of warm-blooded animals. Their identification is possible with a 95 percent confidence by the Fecal Coliform Test (see definition 11, apendix A). There are no acceptable criteria currently recommended. There use in pollution investigations is restricted to:

A Tracing of fecal pollution in water investigations;

B Proof of fecal pollution in waters;

C Comparative studies of maximum hazards in waters having approximately the same coliform densities but differing in the quantity of fecal pollution; or,

D Determining the effectiveness of sewage treatment control measures in receiving waters.

XII INTERPRETATION OF FECAL COLIFORM GROUP

The fecal coliform group is interpreted to indicate:

A Proof of fecal pollution in the water; and,

B It appears to be reasonable assumption that the fecal coliform group would have a greater probability of association with pathogenic entities that members of the coliform group derived from other environments.

XIII THE STREPTOCOCCAL GROUP

A The streptococcal group as an indicator of pollution currently presents a confused situation. This is due to:

1 No uniform agreement of the definition of the group;

2 Failure to observe exact meaning for the terms of "enterococcal group (definition 16)", "fecal streptococcal group (definition 17)" or the practice of using both terms interchangably;

3 The lack of a standardized methodology for their quantitative measurement;

4 Use of various biochemical reactions in their confirmation or the identification of species;

5 Insufficient information on their distribution and survival times in various environmental habitats.

B Disadvantages of the fecal streptococcal group as an indicator of pollution:

1 Their density is considerably less than the coliform density in domestic sewage;

2 The fecal coliform/fecal streptococcal density in human feces is approximately 4.3 to 1.0 ratio;

3 Strains isolated by current methods require detailed and time consuming biochemical tests to establish their applicability.

C Advantages of the fecal streptococcal group as an indicator of pollution:

1 Aftergrowth of the group in waters is generally slight or does not occur;

2 It is a valuable subordinate indicator when, for some reason, the coliform data are subjected to doubt;

3 It is numerically greater than the coliform group in wastes concerned with domestic animal feces such as slaughter house wastes or feed lot wastes, as two examples;

4 Some strains, such as the *Streptococcus bovis* group or *S. equinus* are not found or are statistically insignificant percentage of the strains isolated from the feces of domestic animals.

These characteristics make it a valuable and important group in the tracing of sources of pollution, providing careful and detailed classification and identification of the strains by acceptable methods is made in the laboratory.

D There are no established fecal streptococcal criteria for waters.

APPENDIX A

Differences in the interpretation of terms used in the discussion of microbiological criteria for waters may and frequently does result in confusion in communications. These definitions apply only to the discussion presented in Outline Number 12. No representation is made that these definitions have any general application except for this single presentation.

1 POLLUTION. Pollution means the contamination, or other alterations of the physical, chemical or biological properties of any water, or such discharge of any liquid, gaseous or solid substance(s) into any water, onto or under any land as will or is likely to create a nuisance or render such water(s), or land, harmful or detrimental or injurious to public health or safety or welfare, or to domestic, or commercial, or industrial, or agricultural, or recreational, or other legimate beneficial uses, or to livestock, or wild animals, or domestic animals, or birds, or fish, or other aquatic life.

2 SEWAGE. Sewage means the wastes from toilet(s), bath(s), sink(s), lavatory(ies), laundry(ies), or other plumbing fixture(s) in resident or residences, institution(s), or public or private building(s), mobile home(s), watercraft, collectively or individually, or from any other place of human or animal or avian habitation, employment or recreation and without regard is being sewered or unsewered.

3 FECAL POLLUTION. Fecal pollution is the excreta from the anal orifice of warm-blooded animal life, including humans, domestic or wild animals, or domestic or wild birds.

4 COLD-BLOODED FECAL POLLUTION. Cold-blooded fecal pollution is the excretion from the anal orifice of such living entities which possess the ability to adjust the body temperature to the ambient temperature of the environment.

5 THE COLIFORM GROUP. The coliform group (or coliforms) is a group of bacteria composed of three or more genera with the common characteristics of being (1) Gram negative, non-spore producing rods, (2) growing aerobically and facultatively anaerobically, (3) morphologically resembling Escherichia coli and (4) producing gas in pure culture from the fermentation of lactose in an appropriate medium within 48 (± 3) hours at a temperature of 35 (± 0.5) degrees C.

6 COLIFORM TEST-PRESUMPTIVE. This procedure is the determination of the presence or absence of gas in the inverted vial when the bacteria in the water sample are incubated in lactose broth or lauryl tryptose broth at 35°C for 48 hours.

7 COLIFORM TEST-CONFIRMED. The confirmed test is applied only to positive Presumptive Test reaction. This procedure is the determination of the presence or absence, from an inoculation taken from a positive (gas production) Presumptive tube to (a) brillant green bile lactose broth for the production of gas (positive) or its absence (negative) when incubated at 35°C for 48 hours or less, or (b) the presence or absence of typical colonies resembling those of the coliform group when incubated 24 hours at 35°C, using Eosin Methylene Blue Agar or Endo Medium.

8 COLIFORM TEST-COMPLETED. The Completed Test consists of the isolation of the alleged coliform in pure culture from the plates in the Confirmed Test, using typical colonies or such atypical ones as are colored other than white,

and the demonstration that the pure culture can

a) product gas in the inverted vial when inoculated in lactose broth and incubated at 35°C for 48 hours or less; and,

b) consist of Gram-negative rods, free from spores, which morphologically resemble the coliform microorganism.

9 INTERPRETATION. The limitations of the coliform tests defined under items 6, 7 and 8, using the multiple tube fermentation technique is defined as follows:

a) Presumptive Test when negative excludes the presence of members of the coliform group and the positive reaction presumes the possibility of the presence of members of the coliform group;

b) Confirmed Test when negative proves the absence of the members of the coliform group from the falsely positive Presumptive Test and the positive reaction gives a reasonably strong presumption of the presence of members of the coliform group; and,

c) Completed Test when negative excludes the members of the coliform group from a falsely positive Confirmed Test and when positive proves the presence of the members of the coliform group. It is the reference test described in Standard Methods (S.M., B.3. page 499) and Federal Register, Title 42, Part 72, paragraph 72.207, b 3, page 2155 dated March 6, 1962.

The definitions given under items 6, 7, 8, and 9 apply to the multiple tube feremeentation tests for the coliform group.

10 MEMBRANE FILTER TECHNIQUE. The membrane filter technique consists of the filtration of the sample through a membrane of such porosity (about 0.5 micron) that the coliform and other bacteria present are retained on the surface and the subsequent cultivation of the microorganisms retained on the surface of the membrane on a selective medium which permits the visual identification and counting of the coliform colonies within approximately 24 hours.

The verification of the coliform colonies when needed to establish its validity can be accomplished by procedures (a) and (b) described under item 8.

11 FECAL COLIFORM TEST. The production of gas by the microorganisms contained in a loop from a positive presumptive tube inoculated in EC Medium and Incubated at 44.5 (± 0.5) degrees C is proof of the fecal origin of the strain and the absence of gas indicates the non-fecal origin of the coliform strain.

12 HEALTH HAZARD. A health hazard is any microbiological or environmental situation which creates or may create a danger to health or well-being when the water is used according to the approved legimate water uses.

13 FECAL COLIFORM GROUP. The fecal coliform group is that portion of the total coliform group which has its habitat in the gut of warm-blooded animals.

14 TOTAL COLIFORM GROUP. The total coliform group is composed of all coliform strains which comply with the definition for the coliform group (item 5). This includes those of fecal origin and those from other sources.

15 FECAL STREPTOCOCCAL GROUP. This includes the streptococcal strains commonly present in the gut of warm-blooded animals and expelled in the fecal excretion.

16 ENTEROCOCCAL GROUP (ENTEROCOCCUS). The enterococcal group is a portion of the fecal streptococcal group which have the common characteristics of growth at 45°C and 10°C and can grow in 6.5% sodium chloride broth and broth adjusted to pH 9.6 (The Sherman Criteria).

17 CHARACTERISTICS OF FECAL STREPTOCOCCAL GROUP. The common characteristics of the fecal streptococcal group are (1) round or lancet-shaped organisms in chains of two or more organsims which are Gram-positive, (2) able to grow in 40% bile broth, (3) are catalase negative and (4) produce growth at 45°C or at 45°C and 10°C, excluding the organisms growing at 10°C and not at 45°C (S. loctis group).

This outline was prepared for the Training Program by Harold F. Clark (retired), formerly Bacteriologist, Microbiology, Basic and Applied Sciences Branch, Division of Water Supply and Pollution Control, SEC.

ULTIMATE GOALS IN PUBLIC WATER SUPPLY - CHEMICAL CRITERIA

The Public Health Service Drinking Water Standards are well founded. They are legally applicable only to interstate carrier waters, however, they have been adopted by the entire water works profession as minimum standards for control. They are standards which can be supported as necessary of attainment to protect the public health. The PHS has no legal basis to go beyond that point, minimum standards only being governmental responsibility.

The minimum standards were often cited by laymen, those responsible for financing or managing, and even by some operators, as excuse for mediocrity; passing the minimum standard indicated to them that there was no reason to improve operations or facilities.

The Water Works Profession felt a need for professional quality goals, levels for each individual system to strive toward, an incentive to improvements.(1) The late John R. Baylis, discussing the operators' viewpoint(2) stated, "A standard by which to judge the quality of water is a necessity," and he proceeded to setup his own high standards for systems under his command. The setting up of professional goals, or "ideals," should not be interpreted as a reflection on the PHS; it should rather be an aid to accomplishment of their objectives.

A Committee of the American Water Works Association, on Quality Water Criteria, worked on setting up professional "standards," but concluded that the designation carries with it an implied obligation to attain more than a passing grade, and a stigma of failure for those who cannot meet a schedule promulgated, perhaps through no fault of any person but because of source characteristics, or other circumstances. On the other hand, goals or ideals are desirable in all branches of activity. Therefore "ideals," or goals, as yardsticks of quality, without implications of condemnation for failure, were promulgated.(3) See Table 1.

The levels stated were the best judgment of the Committee as to target levels which could be used in evaluating treated water quality. These are at a level to approach the functionally ideal definition, limited by the sensitivity of present test methods and current medical and sanitary knowledge.

"Ideally, water delivered to the consumer should be clear, colorless, tasteless, and odorless. It should contain no pathogenic organisms and be free from biological forms which may be harmful to human health or esthetically objectionable. It should not contain concentrations of chemicals which may be physiologically harmful, esthetically objectionable, or economically damaging. The water should not be corrosive or incrusting to, or leave deposits on, water-conveying structures through which it passes, or in which it may be retained, including pipes, tanks, water heaters, and plumbing fixtures. The water should be adequately protected by natural processes, or by treatment processes, which insure consistency in quality."

First reaction to the ideal levels may be that they are unrealistic. As standards for compulsory action they would be, but as goals they are not, as is indicated by the degree of present conformance to these ideals. F. B. Taylor(4) found the percentage for interstate water supplies to be as below:

Characteristic	Percent of Supplies in 1961
Color	55
Odor	86
Lead	85
Barium	69
Arsenic	98
Selenium	(78 - 1959)
Cadmium	70
Chromium (Hexavalent)	95
Iron	66
Manganese	35
Copper	70
Zinc	45
Nitrate	92
Filtrable Residue	42
Chloroform Soluble from Carbon Adsorption	(28% less than 0.05 ppm)

TABLE 1

*Ideal Quality Water—Characteristics and Concentrations**

Physical Characteristics	Max. in Ideal Water
Turbidity	Less than 0.1 unit
Nonfilterable residue	0.1
Macroscopic and nuisance organisms	none
Color (true)	3 units
Odor	no change on carbon contact
Taste	none
Chemical Characteristics—Toxic	**Max. in Ideal Water**
Lead (Pb)	0.03
Barium (Ba)	0.5
Fluoride (F)	
Temp—°F†	
50.0–53.7	1.2
53.8–58.3	1.1
58.4–63.8	1.0
63.9–70.6	0.9
70.7–79.2	0.8
79.3–90.5	0.7
Arsenic (As)	0.01
Cyanide (CN)	0.01
Silver (Ag)	0.02
Selenium (Se)	0.01
Cadmium (Cd)	0.01
Chromium (Cr^{+6})	0.01
Total organic phosphorous or chlorinated hydrocarbon insecticides	none‡

Chemical Characteristics—Nontoxic	Max. in Ideal Water
Aluminum (Al)	0.05
Iron (Fe)	0.05
Manganese (Mn)	0.01
Copper (Cu)	0.2
Zinc (Zn)	1.0
Nitrate—inorganic (N)	5.0
Filtrable residue	200.0
Phenolic compounds (as phenol)	0.0005
Chloroform soluble from carbon adsorption	0.04
Alcohol soluble from carbon adsorption	0.10
ABS	0.20
Corrosion & Scaling Characteristics	**Max. in Ideal Water**
Hardness (as $CaCO_3$)	80.0
Alkalinity (as $CaCO_3$)	not more than 1 ppm change§
Coupon tests	3-month tests‖
Bacteriological	**Max. in Ideal Water**
Coliform—multitube fermentation technique#	1 per liter**
Coliform—membrane filter technique	1 per liter**
Radiological	**Max. in Ideal Water**
Gross beta activity	100 pc/l
Radium (Ra^{226})	3 pc/l
Strontium (Sr^{90})	5 pc/l

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* All results in ppm unless otherwise stated.

† Five-year average of maximum daily air temperature.

‡ No appreciable effect on test fish.

§ For decrease or increase in the distribution system also in 12 hr at 130°F in a closed plastic bottle, followed by filtration.

‖ Incrustation rate on stainless steel, not to exceed 0.01 mg/sq cm; loss by corrosion of galvanized iron, not to exceed 5.00 mg/sq cm.

# Completed test or confirmed in accordance with allowed alternate in *Standard Methods.*

** Standard portions of either 10 or 100 ml.

With respect to the physical characteristics, the Drinking Water Standards were set at levels related to consumer acceptance of the water, and avoidance of consumers turning to supplies which might be unsafe. The level of odor threshold of 3 has meaning with respect to any water. Also, with relation to use of natural, unfiltered water the levels of turbidity at 5 units and color at 15 units, can have meaning. However, with filtered water, a content of turbidity or color of more than a small fraction of these amounts would indicate improper operation, questionable safety of the supply, and a water far from ideal. For such waters the turbidity should not be visible in a glass (less than 0.1 unit) and the color should be no more than 3 units. Water of higher content will generally fail to meet the chemical ideals in some respect.

Of the toxics, for Arsenic, Cyanide, Selenium, and Cadmium, the Drinking Water Standards were considered as producing ample safety factors and the sensitivity of test methods do not warrant consideration of lower content. For fluorides there is no existing cumulation of knowledge to equal that considered in establishing the Standards.

Thirteen other chemical characteristics were lowered materially from the Drinking Water Standards in deriving ideal levels. The principal reasons are briefly stated below. (The degree of existing compliance shown herein was not known at the time these ideal levels were formalized.)

Lead: Lead in the atmosphere is increasing. Present individual mean daily intake is 0.3 mg, or over half the allowable without body retention of this cumulative poison. The 0.03 mg/l ideal would limit intake by water to 15 percent of the maximum allowable total daily intake.

Barium: Because of toxic effects on the heart, blood vessels, and nerves, the Standards set 1.0 mg/l as a limit. An ideal should be more than safe and one half the Standard was chosen.

Silver: Silver has been used for water sterilization, 0.01 mg/l being sufficient. At that level it is not an irritant, or toxic. Little data is available as to the effects at higher concentrations.

Chromium (Hexavalent): Significant accumulations have occurred in tissues of rats. Whether it is a carcinogen when taken orally is not known. In view of the lack of knowledge it was classed with Arsenic, Cyanide, Selenium and Cadmium and limited to 0.01 mg/l.

Iron: With iron content above 0.05 mg/l some color may develop and staining may occur.

Manganese: In concentrations of a few hundredths of a mg/l, staining of clothing will occur and black precipitate will form.

Copper: Copper content of 0.5 mg/l, or perhaps less, can cause staining of porcelain (1.0 mg/l will materially affect photographic processes). Even 0.2 mg/l would appear to be something less than ideal as E. W. Taylor(5) has reported that copper salts are responsible for rapid corrosion and perforation of aluminum ware, "Traces only of copper of the order of 0.02 mg/l are necessary to cause severe attack in hard waters, but little trouble with amounts up to 1.0 mg/l is experienced in soft waters".

Zinc: At 5 mg/l a taste may be noted by certain individuals. E. W. Taylor(5) states that, "In acid waters with low concentration of mineral salts, 0.5 mg/l of zinc is toxic to trout, but the fish will tolerate much larger doses in hard waters." Ohio and North Dakota presently have limits of 1.0 mg/l.

Nitrate: Methemoglobinema in infants may be caused by nitrate in water. The Standards set 45 mg/l of NO_3, equal 10 mg/l of N as the recommended limit, but note that, "In areas in which the nitrate content of water is known to be in excess of the listed concentration, the public should be warned of the potential dangers of using the water for infant feeding".

Dr. E. W. Campbell(6) has reported a "blue baby" case which was quite serious, from well water containing 30 mg/l of nitrate equal to 6.75 mg/l nitrogen.

A 1952 USGS (survey) of 1157 supplies revealed that only 10 served water containing nitrate nitrogen of over 5 mg/l.

Filtrable Residue (Total Dissolved Solids): Low solids content is desirable to reduce precipitations when heating or freezing. 200 mg/l is in line with other ideals such as 80 mg/l hardness.

Phenolic Compounds as Phenols: Very undesirable taste results when phenols are converted to chloro-phenols. There is evidence that as little as 0.001 mg/l of phenolics may cause appreciable taste, therefore, one half of that amount was set as the ideal.

Chloroform Soluble from Carbon Adsorption: This material is ill defined and may be definitely toxic. Limiting the total, limits the liability of major toxics being present. Also, there is some correlation between the amount of such material present and taste or odor; the carbon adsorbed organics generally are very high in odor potential. Most of the chloroform soluble materials are generally man-made wastes. Tests of streams remote from concentrated industrial activity or major populations usually show presence of less than 50 parts per billion.

Alkyl-Benzene-Sulfonate (ABS): Because of the aesthetic factors due to foaming, ABS has been of major importance, however, the change of detergents during this year to linear-alkylate-sulfonate (LAS) will cancel the significance of the ABS standard or ideal.

Chlorides and Sulfates: These are each set at 250 mg/l in the Standards; they are not listed in the Ideals, for the limitation of 200 mg/l on filtrable solids precludes a high concentration of either of these.

Corrosion and Scaling Characteristics: A level of 80 mg/l hardness, in terms of $CaCO_3$, was deemed the best--considering all the quality factors and striking a balance between deposition and corrosion. Limitation of the amount of precipitation, or scaling, is reflected in the requirement that alkalinity shall not decrease by more than 1 mg/l, also by the limitation of incrustation on stainless steel coupons in a 90-day period.

Corrosiveness is affected by at least twelve chemical factors: pH, alkalinity, sodium, magnesium, hardness, organic content, carbon dioxide, dissolved oxygen, chlorides, sulfates, phosphates, and total dissolved solids, also by the physical factors of temperature, velocity and turbulence. Determining the corrosiveness by other than actual corrosion effects is therefore nearly impossible. By coupon tests the results have been erratic, but tests are continuing to perfect the procedures.

REFERENCES

1 Bean, E. L. Need for Professional Standard. Jour. Amer. Water Works Assn. V. 52, p 1176. Sept. 1960.

2 Baylis, J. R. Water Quality Standards - Operator's Viewpoint. Ibid. V. 52, p 1169. Sept. 1960.

3 Bean, E. L., et al. Progress Report on Water Quality Criteria. Ibid. V. 54, p 1313. Nov. 1962.

4 Taylor, F. B. Effectiveness of Water Utility Quality Control Practices. Ibid. V. 54, p 1257. Oct. 1962.

5 Taylor, E. W. Examination of Waters and Water Supplies. Little, Brown and Co., Boston, Mass. 1958.

6 Campbell, E. W. Personal communication.

This outline was prepared for the Training Program by E. L. Bean, Chief, Treatment Section, Philadelphia Water Department, Philadelphia, Pennsylvania.

WATER QUALITY FOR RECREATION

Dr. Allan Hirsch, Program Officer, Division of Water Supply and Pollution Control, Public Health Service will present the subject relating to water quality for recreation. The discussion will be introduced with comments on water - based recreation needs and the role of recreation in determining water pollution control policies.

In addition, Dr. Hirsch will cover the following items in his lecture:

RECREATION AND WATER QUALITY - PROBLEMS OF EVALUATION

Physical

Economic

QUALITY CRITERIA FOR RECREATION

Water-contact Sports

Aesthetics

Fish and Wildlife

RESEARCH NEEDS

CONSERVATIONISTS' VIEWS OF WATER QUALITY MANAGEMENT

Conservationists are vocal about things they believe in. It may be presumptuous but they often consider themselves the voice of the nation's conscience on natural resourse use. To the dedicated conservationist, water quality deterioration is an emotional problem. Conservation needs in water quality cannot all be measured in the laboratory. Who can evaluate in dollars an outdoor recreational experience destroyed by pollution? Or the loss of a sport fishery population? Who can count the cost of generations of youngsters who will never know the fun they might have had, if the stream or lake nearby is denied them by filth?

A conservationist is a crusader. Given to exaggeration for effect, he frequently arouses the ire of the resource spoiler and the research scientist alike. But who can deny the value of a Silent Spring? The war for clean water cannot be won in the laboratory alone.

I offer no scientific proof that water pollution is the greatest conservation problem in America today, but I do speak for conservationists across the nation. This is our number one target - for preservation of our resource heritage, for providing maximum outdoor recreational opportunities, and for safeguarding human life itself.

Municipal and industrial wastes dumped into our streams offer threat enough but now we must be concerned also with radioactive materials, detergents and dangerous pesticide residues. We can see and smell sewage, but what will warn us of lethal concentrations of chlorinated hydrocarbons?

At a Congressional budget hearing a few years ago, a representative of the Bureau of Sport Fisheries and Wildlife told our lawmakers that "we are losing more wildlife habitat to pollution each year than is being created or restored by all federal and state conservation efforts combined." I cannot prove that claim, nor do I know if our losses and gains continue in the same trend, but I do know that we have destroyed vast water areas for wildlife production.

I have seen acid mine drainage destroy repeatedly all fish life in Cedar Creek almost within sight of my home. It is a documented fact that a once flourishing commercial and sport fishery in the Mississippi River has been virtually wiped out for 150 miles below St. Louis. We need only to look upstream to a highly developed recreational area and a profitable commercial fishery to see what a metropolitan complex like St. Louis can do to a river.

Last spring we sat by helplessly and watched fish dying in rivers, ponds and drainage ditches across southeast Missouri. Our own biologists observed spray planes with toxaphene go from field to field spraying for army worms in wheat, not bothering to turn off the spray while crossing water. Minutes later, dying fish would rise to the surface exhibiting all the symptoms of pesticide poisoning. Yet, we were accused of "crying wolf" and falsely blaming the spraying operations for the fish kills.

A few days later as the growing season and the army worm advanced and spraying operations moved to the Missouri River bottoms, large quantities of dead fish appeared in this mighty river. We cannot pinpoint the exact time or location of the kills, which numbered in the hundreds of thousands of fish by actual count, but we were severely criticized for even hinting that it might be pesticides that were responsible. I was called on by both chemical manufacturers and agricultural interests, each greatly alarmed because we even suspected agricultural spray - without proof. My staff of biologists underwent a thorough grilling by a Congressional team of investigators. We still do not know positively what killed the fish, but perhaps we learned a valuable lesson on the necessity for early action to collect evidence in case of a future occurrence.

Last year I attended the conference called at New Orleans on the massive fish kill which took place a year earlier in the lower Mississippi. Never have I seen a more convincing presentation of scientific evidence as to the cause of these fish deaths. Clearly and without question or doubt in my mind, the finger pointed at the chemical compound, endrin, which appeared in lethal quantities both in water samples and dying fish. But, you know the rest of the story as well as I - denial by agricultural interests that land spraying could possibly be the source of the poison; denial by the endrin manufacturer, Velsicol, at Memphis that their plant could be the source; Congressional hearings both lauding and discrediting the findings of the Public Health Service investigators.

Did Americans learn anything from this episode? Were all possible precautions taken to prevent a reoccurrence? Our answer to that came in the emphatic negative just a month or so ago with the disclosure that four tons of endrin were found in an interceptor sewer at Memphis leading directly from the Velsicol plant. Is there any wonder that we conservationists get emotional over water pollution? If we don't raise a cry of alarm - who will?

But, perhaps in my emotionalism I have thus far ignored my specific assignment on this panel. I am to discuss the conservationists' views of water quality management. This is easy - we're too little and too late in getting underway. It's time to wake up and get to work. We have had too much time wasted in trying to justify this water management disgrace that we term pollution and in trying to define maximum tolerances for water contaminants.

We need a whole new national philosophy on water quality. We must start thinking in terms of keeping water as clean as practical, not in how much filth can be tolerated. You will notice I said "clean as practical" and not "clean as possible." Conservationists are not unreasonable, but there has been too much emphasis on minimum acceptable water quality standards. Let's begin to emphasize clean water in the positive instead of negative allowable contaminants. I am reminded of a favorite phrase of one of my fellow conservation directors - "Dilution of pollution if no solution."

What are the conservationists' principal interests in water quality? Again, I cannot help being somewhat emotional. We are interested in survival, for ourselves and our children. We want to protect our own lives as well as the lives of wild and domestic animals entrusted to our care. We want to preserve the ecological communities of lakes, estuaries, marshes and streams. Our interests are not only biological but esthetic. Our lives can be better if we preserve both the beauties and the balances of nature.

Conservationists recognize that resources are our true wealth - that we will prosper as a nation only so long as we have an abundance of minerals, productive soils, timber, wildlife, pure air and clean water. Our usable water supplies are not inexhaustable; they can be used up. But worse yet, they can be made unfit for use. This we have done in many places, not only endangering health and destroying natural beauty, but limiting our productive capacity and thus our economic growth.

Recreational needs in water quality management are thought by many to be the only interests of conservationists. Certainly this is not true, but recreation does rank high on our list of uses for clean water. Fishing, hunting, swimming, boating, camping, picnicking, and just plain sightseeing are water uses directly related to water quality and pollution. All suffer as water quality diminishes.

We all know many miles of streams rendered unfit for fishing, swimming and boating by municipal and industrial waters. The Missouri River flows at the front door of my home town, Jefferson City; yet, none of my many boating friends would think of putting a pleasure boat in its waters, let alone swimming or water skiing there. Instead, they drive sixty miles each weekend to the Lake of the Ozarks, though I understand that health authorities are now quite alarmed by the organic concentrations building up along its highly developed shorelines.

Fish and wildlife losses emphasize deterioration of water quality quickly and dramatize the effects of pollution. We have witnessed large waterfowl kills as the result of oil pollution. Shellfish industries have been wiped out by estuarine pollution. Fish kills have become the national barometer of water pollution. This has made conservation agencies the target for abuse of those resisting pollution controls. Nevertheless, we are proud of our role in focusing attention on this great conservation problem.

Questions have been raised as to the relative importance of a few dead fish or a few ducks as compared with sewage problems of a vast city or the production of a large industrial plant and the economy of a community. Perhaps in measure of dollars we cannot condemn all waste discharges that kill wildlife. It has been asked: Which is the more important, fish or people? Certainly people are our greatest concern, but fish and game are important to people. Life is not all food, shelter and modern conveniences. We need the relaxation of body and mind provided by fish and fishing, by ducks and hunting, by recreation beside a clean lake or river, and the regenerative value of a beautiful countryside.

Recreational uses of water should rank along with others considered more important. Instead, recreation is often relegated a position at the bottom of the list after domestic uses, industrial, irrigation, agricultural and other needs have all been met. Generally, recreational uses of water are non-consumptive and do not render water unfit for other uses. Fishing, swimming and boating impair neither the quantity nor the quality of our water resources. Perhaps this is why conservationists are so critical of those uses which destroy water quality for recreational purposes.

Conservationists also have a political concern for water quality. We feel that progress in pollution abatement is not fast enough. Stronger efforts on the national, state and local levels all are needed. Too much of our water pollution control programs have been oriented to the public health aspects of the problem. One need which we feel very strongly is for a higher water pollution control administration at the federal level. Water pollution is much more than another environmental health problem. Federal actions must be intensified and this is not likely to happen at the program's present administrative level. We are not trying to take water pollution out of the Department of Health, Education and Welfare and transfer it to the Interior Department, but only to build stronger emphasis and more decisive action into the pollution control effort. If this cannot be done in its present department, then perhaps it should be transferred to another agency; but, first, let's give a separate administration a chance to accomplish what has not been forthcoming through the Public Health Service.

Conservation forces are proud of the leadership which they have exerted in the water pollution control field. Maybe we are emotionally motivated, but our concern is genuine and honest. We sincerely believe that water pollution is the nation's top priority natural resource problem, and we will continue our fight for clean water. We appreciate all the help we can get from whatever source and pledge ourselves anew as the watchdogs of all our natural resources.

This outline was prepared for the Training Program by William E. Towell, Director, Missouri Conservation Commission, Jefferson City, Missouri.

Outline Number

QUALITY, NEEDS AND EFFECTS OF AGRICULTURAL USERS

Quality - Criteria for Irrigation 18

Need for and Value of Water for Agriculture 19

Effects of Irrigation Return Flows 20

QUALITY - CRITERIA FOR IRRIGATION

I QUALITY CRITERIA FOR IRRIGATION

A The Importance of Irrigation Agriculture

1 In 1960,(1) water users in the United States withdrew approximately 270 bgd of water.(2) Industry withdrew 51 per cent of this volume, but consumed only about 2 percent of what it withdrew. Irrigation diverted somewhat less than industry, or about 110 bgd (including conveyance losses). Irrigation, however, consumed a much larger proportion of what it withdrew - about 66 percent.

2 Irrigation makes farming possible in arid or desert regions.

3 Irrigation enables farmers to diversify and change from crops in surplus supply to crops in demand.

4 Crops produced under irrigation account for one-third of the value of all crops harvested in this country.

B Quality Criteria for Irrigation Water(3)

1 Total salinity

a **Description.** In any solution of electrolytes, including irrigation water, the quantity of cations (positive ions) present is chemically equivalent to the quantity of anions (negative ions) present. In natural waters the more important cations are calcium, magnesium and sodium and the more important anions are bicarbonate, sulfate, and chloride. Potassium, carbonate, fluoride and boron and possibly other constituents may be present in low, but significant, concentrations.

b **Measurement.** The most common measure of total salinity of irrigation waters is electrical conductivity. It correlates well with the sum of cations (or anions) as determined by chemical analysis and with dissolved solids determined by evaporation.

c **Range.** More than half of the irrigation waters in use in Western United States have conductivity values below 750 micromhos/cm (about 500 mg/l dissolved solids). The more saline waters with conductivity values greater than 2250 micromhos per cm (about 1500 mg/l dissolved solids) make up less than 10 percent of the total number of waters and an even smaller fraction of the total quantity of water being used.

d **Effects.** Barring dilution by rain, the soil solution, from which the plant roots take water, is at least as saline as the irrigation water and may be several times as concentrated. Plant growth is inhibited or prevented by higher concentrations of salt in the soil solution.

2 Sodium

a **Description.** The sodium hazard of an irrigation water depends on the quantity of sodium present and its relation to the dibasic cations calcium and magnesium.

b **Measurement.** The most reliable index of the sodium hazard, or the tendency of an irrigation water to form exchangeable sodium in the soil, is the sodium-adsorption-ratio, SAR. It is a calculated value and is defined as:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}} \qquad (1)$$

where the concentrations of the ions in the irrigation water are expressed in meq/l.

c Range. The SAR of most surface waters is low. Some ground waters have high values. For safe use, the SAR of an irrigation water should not exceed about 8.

d Effects. Sodium is essentially unique among the cations in its effect upon the soil. When present in the soil in exchangeable form, even at low concentrations as compared with the other cations, it causes adverse chemical and physical conditions to develop. Exchangeable sodium tends to make a moist soil impermeable to air and water, and upon drying such a soil is difficult to till. Dense crusts form that interfere with germination. In addition to these adverse physical reactions, sodium is toxic to some plants.

3 Bicarbonate

a Description. This constituent is important primarily in its relation to calcium and magnesium. There is a tendency for calcium, and to some extent magnesium, to react with the bicarbonate and precipitate as calcium carbonate (limestone). As calcium and magnesium are lost from the water, the relative proportion of sodium is increased with an attendant increase in the sodium hazard.

b Measurement. Eaton(4) proposed the term "Residual Sodium Carbonate", RSC, as a measure of this hazard and defined it as:

$$RSC = (CO_3^{--} + HCO_3^{-}) - (Ca^{++} + Mg^{++}) \qquad (2)$$

in which the concentrations are expressed in meq/l.

c Range

1) RSC is low in most surface waters. Many ground waters are marginal or too high. If the RSC is more than 2.5 meq/l, the water is probably not suitable for irrigation purposes. Waters containing 1.25 to 2.5 meg/l are marginal, and those containing less than 1.25 meq/l RSC are probably safe.

2) A new approach to this problem has been worked out recently by Bower and Maasland(5), but time and space limitations of this course do not permit further elaboration.

d Effects. The effects are the same as described under Sodium, above.

4 Boron and other phytotoxic substances

a Description

1) Boron. Boron is the characteristic element in such well-known compounds as borax and boric acid. It is found in practically all natural waters, the concentrations ranging from traces to several mg/l. It is essential to normal plant growth but exceedingly toxic at concentrations only slightly above optimum.

2) Other phytotoxic substances. In rare instances, lithium occurs naturally in toxic concentrations. Also, the pollution of surface and ground waters with industrial wastes presents a very real hazard. This is discussed by Wilcox(6) but cannot be elaborated further in this outline.

b Measurement. Permissible limits of boron in irrigation water and the boron-tolerance of crop plants are reported by Wilcox.(7)

c Range. Boron is low in most surface waters but many ground waters contain marginal or toxic concentrations. Less than 1 mg/l boron, B, in irrigation water is safe for even boron-sensitive crops. Semitolerant crops will take up to 2 mg/l B and tolerant crops to 4 mg/l.

d Effect. Boron tends to accumulate in the mature leaves of many plants. This results in yellowing or burning of the leaves and in premature abscission with consequent reduction in yield.

C Classification of Irrigation Waters

The suitability of a water for irrigation depends on several factors in addition to the chemical characteristics discussed in this outline. Other factors that must be taken into account include infiltration rate and drainage of the soil, quantity of water used, climate, rainfall, and salt tolerance of crop.

D Summary

Much work has been done on developing quality criteria for irrigation water. Salt-tolerance of crops, drainage of soils and management practices have also been investigated and must be taken into account in assessing the suitability of a water for irrigation.

E Supplementary Irrigation in Humid Regions

The discussion above applies only to irrigation under aric conditions and is not directly applicable to humid regions. Lunin et al.(8) studied supplementary irrigation along the Eastern Seaboard. It was found that occasional irrigations with relatively saline water were permissible under those conditions.

REFERENCES

1 Wilcox, L. V. Salinity Caused by Irrigation. Amer. Water Works Assoc. Jour. 54:217-222. February, 1962.

2 MacKichan, K. A. Water Use in the United States, 1960. Amer. Water Works Asso. Jour. 53:1211. October, 1961.

3 Wilcox, L. V. Classification and Use of Irrigation Waters. U. S. Dept. of Agric. Circular 969. GPO. November, 1955.

4 Eaton, Frank M. Significance of Carbonates in Irrigation Waters. Soil Sci. 69:123-133. 1950.

5 Bower, C. A. and Maasland, M. Sodium Hazard of Punjab Ground Waters. West Pakistan Engineering Congress Proc. pp 49-61. 1964.

6 Wilcox, L. V. Effect of Industrial Wastes on Water for Irrigation Use. American Society for Testing Materials Symposium on Technical Development in the Handling and Utilization of Water and Industrial Waste Water. Special Technical Publ. No. 273:58-64. 1959.

7 Wilcox, L. V. Boron Injury to Plants. U. S. Dept. Agric. Agriculture Information Bulletin No. 211. 1960.

8 Lunin, Jesse, Gallatin, M. H., Bower, C. A., and Wilcox, L. V. Use of Brackish Water for Irrigation in Humid Regions. U. S. Dept. Agric. Information Bulletin No. 213. 1960.

This outline was prepared for the Training Program by L. V. Wilcox, Consultant, 5218 Brockton Avenue, Riverside, California.

NEED FOR AND VALUE OF WATER FOR AGRICULTURE

I VOLUME OF AGRICULTURE WATER

A Present Use

Agricultural water uses may be broadly grouped into three categories:

1 Livestock and poultry drinking water

2 Washing and sanitation use - farm

3 Irrigation

Aggregative data on volume of water used by livestock and poultry and for farm washing and sanitary purposes in the United States are generally not available. While water supplies for these uses is important, the volume required is relatively small.

Irrigation is by far the greatest single use of water in the United States, accounting for over two fifths of the total water used. In some basins in the arid west, irrigation accounts for over 90 percent of the total water used.

The daily average use of water for irrigation in this country was 135 billion gallons in 1960. (414,300 AF)(151,219,000 AF Annual).

In 1960, 33.2 million acres were irrigated. Of these 30.7 million acres or 92.7 percent were in the 17 western states.

The volume of irrigation water used has steadily increased. The increase in water used for irrigation and acreage irrigated during the period 1940 - 1960 has been fairly consistent. The annual rates of increase were 3.3 percent for volume of irrigation water used and 3.1 percent for acreage irrigated. For comparison purposes, the annual rate of increase in all other withdrawal water uses, during the same period, was 4.2 percent. The annual rate of population growth in the Continental United States was 1.5 percent, Tables 1 and 3. The rate of increase of irrigation water use was more than double the population growth rate.

B Future Irrigation Use

The consistent historical upward trend in both the volume of irrigation water used and irrigated acreage in combination with private, state, and federal irrigation water developments under construction and in the planning stage, indicate strongly that the volume of irrigation water use will continue to increase in the foreseeable future. While the annual rate of increase is likely to be greater in the 31 eastern states, the increase in the numerical quantity is likely to continue to be much greater in the 17 western states.

Some areas of the west, particularly in the Rio Grande and Colorado River Basins and in the Great Basin, are running out of local developable water. This inconvenience, however, is being met by proposals for massive interstate and interregional water storage and transfer systems to import water into the deficit areas.

The U. S. Department of Commerce, Bureau of the Census, projects an increase in irrigation water use between 1960 and 1980 of 31.9 percent. This is equal to an annual rate of increase during the 20 year period of 1.4 percent.

The U. S. Department of Agriculture, at the request of the Senate Select Committee on National Water Resources, developed estimates, in 1959, of the future needs for irrigation water. Their report shows that in 1954 storage and diversion of water for irrigation was 195 million acre feet of which 115 million acre feet were actually used for irrigation, Table 2. Under medium level population projections, the Department estimates that water requirements for irrigation in 1980 will be

TABLE 1

WATER USE IN UNITED STATES 1940-60 AND PROJECTED TO 1980
(In Billions of Gallons, Daily Average)

Year	Total Water Use				Irrigation		All Other Withdrawal Use	
	Total	Percentage Increase	Ground	Percentage Increase	Total	Percentage Increase	Total	Percentage Increase
1940	136.43		22.56		71.03		65.40	
1945	170.46	24.9	28.33	25.6	83.06	16.9	87.40	33.6
1950	202.70	18.9	35.19	24.2	100.00	20.4	102.70	17.5
1955	263.80	30.1	47.79	35.8	116.30	16.3	147.50	43.6
1960	322.10	22.4	58.17	21.7	135.00	16.1	187.90	27.4
Projected								
1980	494.10		84.94		178.00		316.10	
1940-60		136.7		157.8		90.1		187.3
Annual Rate		4.4		4.2		3.3		4.2
1960-80		53.40		46.0		31.9		68.2
Annual Rate		2.2		1.9		1.4		2.6

Source: U. S. Department of Commerce, Bureau of the Census

TABLE 2

PROJECTED IRRIGATION WATER REQUIREMENT
(In Millions of Acre Feet)

	1954	1980			2000		
		Low	Medium	High	Low	Medium	High
Storage and diversion	195	174	181	255	143	199	255
Irrigation	115	110	114	145	96	137	181
(Without improvement in efficiency of storing, transportation, and using)						307	
			Percentage Change		Percentage Change		
Irrigation		(1954-80) Less than -0.1			(1980-2000)	20.2	
Annual Rate						0.9	

Source: U. S. Department of Agriculture, U. S. Senate Select Committee Print No. 12

TABLE 3

LAND IRRIGATED IN THE UNITED STATES
(In Thousands of Acres)

Year	Total Acreage Irrigated		17 Western States		31 Eastern States	
	Total	Percentage Increase	Total	Percentage Increase	Total	Percentage Increase
1940	17,983		17,243		740	
1945	20,539	14.2	19,431	12.7	1,108	49.7
1950	25,787	25.6	24,271	24.9	1,516	36.8
1955	29,552	14.6	26,971	11.1	2,581	70.2
1960	33,163	12.2	30,738	14.1	2,425	- 6.0
1940-60		84.4		78.3		227.7
Annual Rate		3.1		2.9		6.0

Source: U. S. Department of Commerce, Bureau of the Census only 181 million acre feet for storage and diversion with 114 million acre feet actually used for irrigation. This projection indicates a small net decline in irrigation water use from the 1954 level.

By the year 2000, even though requirements for agriculture production are assumed to be twice the 1954 level, the Department estimates the water requirements for storage and diversion may be only 199 million acre feet with irrigation use of 137 million acre feet. However, if there is no improvements in the efficiency of storing, transportation and using irrigation water, the Department estimates tremendous additional amounts of water would be required for irrigation, as much as 307 million acre feet by the year 2000. Adoption of known improved metnods of water management for irrigation and continued research and education are relied upon by the Department to achieve the reduction in future irrigation water requirements.

The actual increase in use of irrigation water between 1955 and 1960 of 22 percent, however, provides no assurance that the Department's forecast of a drop in use from the 1954 level will materialize by 1980. The inverse relationship between irrigation efficiency and concentration of TDS in return flows which is contributing to the growing salinity problem in the lower reaches of many rivers, such as the Colorado River in California and Mexico, the Sevier River in Utah, the Humbolt River in Nevada and the San Joaquin River in California, may also prove to be a sizeable stumbling block to the attainment of the expected increase in the aggregate efficiency of irrigation water use.

The Department's estimate of irrigation use of 307 million acre feet by the year 2000 may well prove to be more reliable than their estimate of 137 million acre feet. The higher use is equivalent to a mean annual rate of increase of 2.2 percent and is approximately two thirds of the recent historical rate of increase.

To summarize: The need for agriculture water is dependent upon the need for agricultural production. The volume of agriculture production needed is dependent upon population. As population increases, the use of irrigation water is also likely to increase. The annual rate of increase in irrigation water use between 1940 and 1960 was 3.3 percent. The Department of Commerce projection is equivalent to an annual rate of increase between 1960 and 1980, of 1.4 percent. Without improvement in efficiency, the Department of Agriculture's estimate for the year 2000 is equivalent to an annual increase in irrigation water use of 2.2 percent. The prudent forecaster may well select a future rate of increase in use of irrigation water falling between 1.4 and 2.2 percent annually.

II VALUE OF IRRIGATION WATER

The value of irrigation water has and continues to provide an area of economic research and popular debate for the non-economist as well as for the economist. I do not believe there is any other single commodity which has been so exhaustively studied and which still remains so debatable as the value of irrigation water. This may be due to the fact that water has some unique characteristics which are possessed by no other good or service used in agricultural production. It moves under its own power, downhill of course, and through the earth as well as on the surface. This characteristic alone makes ownership of water ellusive, inhibits water transfers, and provides the courts with a continuous supply of grist for the judicial mill. Waters use as a universal solvent and economical medium for disposal of wastes is also unique - natures provision of a natural sewerage system for the disposal of man's as well as the earth's wastes further complicates the evaluation picture.

Another rather unique characteristic of the value of irrigation water is what might be called its localized nature. The price of practically all other goods and services used in the production of irrigation crops is national in scope. That is, the local price is primarily dependent upon the cost of production including the profit margin, the freight differential, and the volume used locally. The range in unit cost of production between plants in the United States is relatively narrow for a given quality of product but is markedly influenced by differences in quality. Not so with water. The price of water is determined locally, it varies widely from area to area and is primarily dependent upon supply available and cost of production (development), freight costs between areas are prohibitive-non effective and, therefore, the impact on price of variations in quality and volume used is severely restricted.

The final constraint on the economic value of irrigation water, as well as other goods and services is, of course, the value or satisfaction derived from its use.

While we have one national market for other goods and services, we have an innumerable number of local markets for water. It should, however, be recognized that we are currently in the throes of consolidating many local water marketing areas by massive development of integrated river basin and interbasin storage and distribution systems which is profoundly effecting both the number of local marketing areas and the price of water within the consolidated service areas. The resultant movement in unit price of water is generally up.

Rather than attempt further discussion of the impact of the above characteristics on the value of irrigation water, my subsequent discussion is restricted to a brief, broad gaged description of the principal measures of value which are currently in vogue. These are:

1 Gross value of irrigated crops produced.

2 Direct and indirect benefits resulting from use of irrigation water.

3 Farm repayment capacity for water.

4 Market price for irrigation water.

5 Cost of developing irrigation water supplies.

These measures are frequently used for various purposes. The one common characteristic is that the range in value between geographical location is usually wide.

A Gross Value of Irrigated Crops Produced

This is an expression of the gross market value, at the farm, of crops produced under irrigation. It is not an expression of the economic value of irrigation water per se since water is used in combination with land and many other goods and services in producing crops. Values are usually expressed in terms of a geographical area, per irrigated acre, or per acre foot of water used. The principal use of this measure of value is to indicate the relative contribution to the overall economy of irrigated agriculture. The value per acre foot of water used is frequently compared to gross value of product or value added per acre foot of water when used for other purposes, such as power, recreation and various categories of manufacturing. In this comparison, irrigation normally has the lowest value per acre foot of water used. To illustrate, Wollman, in a detailed study of water use in the Albuquerque area, New Mexico, arrived at the following values added per acre foot of water use:

Industry	$3,040 to 3,989
Recreation	212 to 307
Agriculture	44 to 51

Such arrays are useful indicators of the relative value of water but should not be used as the sole basis for advocating the reallocation between uses of existing water supplies or of forecasting future water uses. Two primary reasons for exercising caution in this respect are (1) the quantity of water required by industry is currently relatively small in relation to irrigation use and the quantity required in the future is also likely to be relatively small. (2) A large portion of industrial activity, at least in many areas of the west, depends upon the irrigated farm for either raw materials or markets for commodities manufactured. The interdependency of water supplies for agriculturally oriented industries and irrigation should not be overlooked.

B Direct and Indirect Benefits Resulting From Use of Irrigation Water

Direct and indirect irrigation benefits are imputed values developed primarily by the construction agencies and the universities. Direct benefits are defined as the increase in gross value of agriculture production resulting from use of irrigation water, developed by a project, less associated costs. They are developed by the use of farm budget and crop budget analyses. Indirect benefits are defined as increases in net incomes of local people derived from processing, warehousing, and transporting the increased volume of agricultural commodities produced and the increased volume of goods and services required in irrigated farm operations. The total of the direct and indirect benefits represents the increase in personal income within the local economy. As such, the measures of value also represents a gross measure of the contribution to the economy but is usually restricted to the contribution resulting from development of specific blocks of water for irrigation use.

C Farm Repayment Capacity for Irrigation Water

Farm repayment capacity for irrigation water is perhaps the best measure of the economic value of water per se. It, too, is an imputed value derived from farm budget and crop budget analyses in specified local areas. The imputed value represents what the farmer could pay for water without impinging on the going rate of return to other factors used in production. Due to differences in climate, soil fertility, cropping pattern and size of farm, these imputed values vary widely between areas, ranging from negative value to more than $30.00 per acre foot.

D Market Price for Water

A well organized market for the free transfer of water does not exist. The market for water is restricted by water laws, uncertain and illusive ownership problems, transportation problems and the effects on water users other than the two parties directly involved in the exchange. Third and fourth parties are frequently effected by water transfers between individual users. Some exchanges do, however, occur in local areas. A well organized water market exists in Delta, Utah, the lowest irrigated area in the Sevier River Basin. In this area, water moves freely between farmers within the service area of four irrigation companies which operate an integrated storage and distribution system from one central office. Farmers buy and sell water freely. Individual transactions are registered at the central office which debits and credits individual water accounts and makes deliveries to each individual on his order until his water account is exhausted. The effect of supply and demands is plainly evident. During wet years, the price of water is relatively low and during dry years, is high ranging from about $5.00 to $20.00 per acre foot. Market prices for water where they occur generally, compare favorable with imputed values derived from repayment capacity studies. A somewhat analogous system is developing in the Central Valley project service areas in California. The Bureau of Reclamation, however, controls the price.

E Cost of Developing Irrigation Water Supplies

The vast majority of irrigation water supplies have been developed by individual farmers, mutual irrigation companies, and irrigation districts. The cost to the farmer is determined by the cost of developing storage, diversion, and distribution systems. These organizations also contract with the Federal and state agencies for water supplies. According to the U. S. Census of irrigation the cost of water delivered to farmers by irrigation companies generally ranges downward from about $5.00 per acre foot annually. Current costs of developing additional increments of water are usually much higher.

III IMPACT OF QUALITY ON VALUE OF IRRIGATION WATER

Information from research studies specifically designed to determine the effect of quality on the economic value of irrigation water is generally not available.

This statement should not be interpreted to mean that information on the chemical constituents found in surface and underground water supplies and their chemical and physical effects, when used for irrigating, on soils, plants, and irrigation farm management are not available. These chemical and physical effects have been extensively studied. Various methods of classifying irrigation water have also been developed. What it does mean is that one rarely finds in the literature a dollar sign attached to irrigation water quality classification.

The growing importance of the economic value of quality is evidenced by the increasing number of recent irrigation water delivery contracts which contain specifications as to water quality as well as quantity. In California, water quality is rapidly becoming a prime consideration in contract negotiations of both the State Department of Water Resources, The Bureau of Reclamation and the water users. And, I should add, a major deterrent to the satisfactory completion of many contracts.

Also, the economic and social costs attached to deteriorating irrigation water quality in the lower reaches of the Colorado River in California and Mexico and the San Joaquin River in California is generating an outcry from existing water users of major significance. Other uses of water are, of course, also involved.

The chronic need for economic interpretation of irrigation water quality, as well as quality of water for other uses, is rapidly becoming acute. I believe reliable information on the dollar value of water as affected by quality would materially assist in the intelligent solution of present and future water quality controversies. This water quality - economic value field is essentially wide open. Due to the supercharged emotional and political atmosphere surrounding water, those who enter the field should, however, be equipped with a thick skin and bulldog persistence.

The problems encountered in determining the economic impact of water quality on irrigated agriculture are exceedingly complex. Ideally, economic impact could be determined by farm budget studies of typical irrigated farms with all variables held constant except water quality. The impact of variations of quality on farm operating costs and crop yields would be reflected as differences in net farm income. Such studies are, however, time consuming. Also, the physical quantification and pricing of the effects of water quality on farm operation costs and crop yields would entale detailed field work.

These effects, listed below, are well known in general terms, but their numerical relationship to quality differences have not been adequately established.

1 Quantity of water required for leaching to prevent accumulation of excessive salts in the soil.

2 Costs of applying quantities of water for leaching.

3 Drainage costs to remove and dispose of water applied for leaching.

4 Fertilizer losses resulting from leaching.

5 Costs of laboratory testing to insure maintenance of salinity concentrations in the soil solution within crop tolerance limits.

6 Frequency of irrigation.

7 Excessive corrosion of metal irrigation facilities.

8 Seed germination and plant establishment failures necessitating replanting.

9 Reduction in crop yields due to salinity damage.

10 Changing the method of irrigation and cultural practices

11 Changes in soil permeability.

12 Forced substitution of salt tolerant crops for salt sensitive crops due to excessive salinity.

13 Destruction of agriculture productivity of irrigated land due to excessive salinity and associated water logging.

In Region IX, the U. S. Public Health Service recently completed a water quality control study wherein a short-cut method was used to approximate the economic impact on agriculture of differences in quality of irrigation water. In this study, we used total dissolved solids as the water quality parameter. In general, the procedure involved the determination of the increases or decreases, in acre feet, of water required for leaching and disposal of the salts. These differences were then multiplied by the economic value of water to agriculture, per acre foot consumptively used, to obtain an estimate of salinity pollution damages in the case of an increase in salinity in irrigation waters and, conversely, an estimate of the benefits resulting from decreases in salinity in irrigation water.

Our approach to this evaluation problem and our results has stimulated considerable comment and discussion both favorable and unfavorable. We consider the methodology theoretically sound within the range of salinity which the farmers can adjust to by modifying their water management practices. The accuracy of the results is dependent upon the accuracy of our estimates of the four parameters utilized.

The methodology can be employed to develop a value quality curve for irrigation water delivered to the farm headgate for a given service area, as illustrated in Figure 1. This curve would of course be different for different irrigated areas due to changes in value of the individual parameters.

REFERENCES

1 Wollman, Nathaniel. The Value of Water in Alternative Uses. The University of New Mexico Press, Albuquerque. 1962.

2 U. S. Department of Health, Education and Welfare, Public Health Service, Region IX, San Francisco, California. Water Quality Control Study, Peripheral Canal, Sacramento - San Joaquin Delta, California.

3 Senate Select Committee on National Water Resources, United States Senate, Committee Print No. 12, Water Resources Activities in the United States. 1960.

4 U. S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States. 1962.

5 Financial Compound Interest and Annuity Tables, Third Edition, Financial Publishing Company. 1961.

6 U. S. Department of Agriculture, U. S. Salinity Laboratory Staff. Diagnosis and Improvement of Saline and Alkaline Soils, Agriculture Handbook No. 60.

7 State of California, State Water Quality Control Board, Sacramento, California, Water Quality Criteria. 1962.

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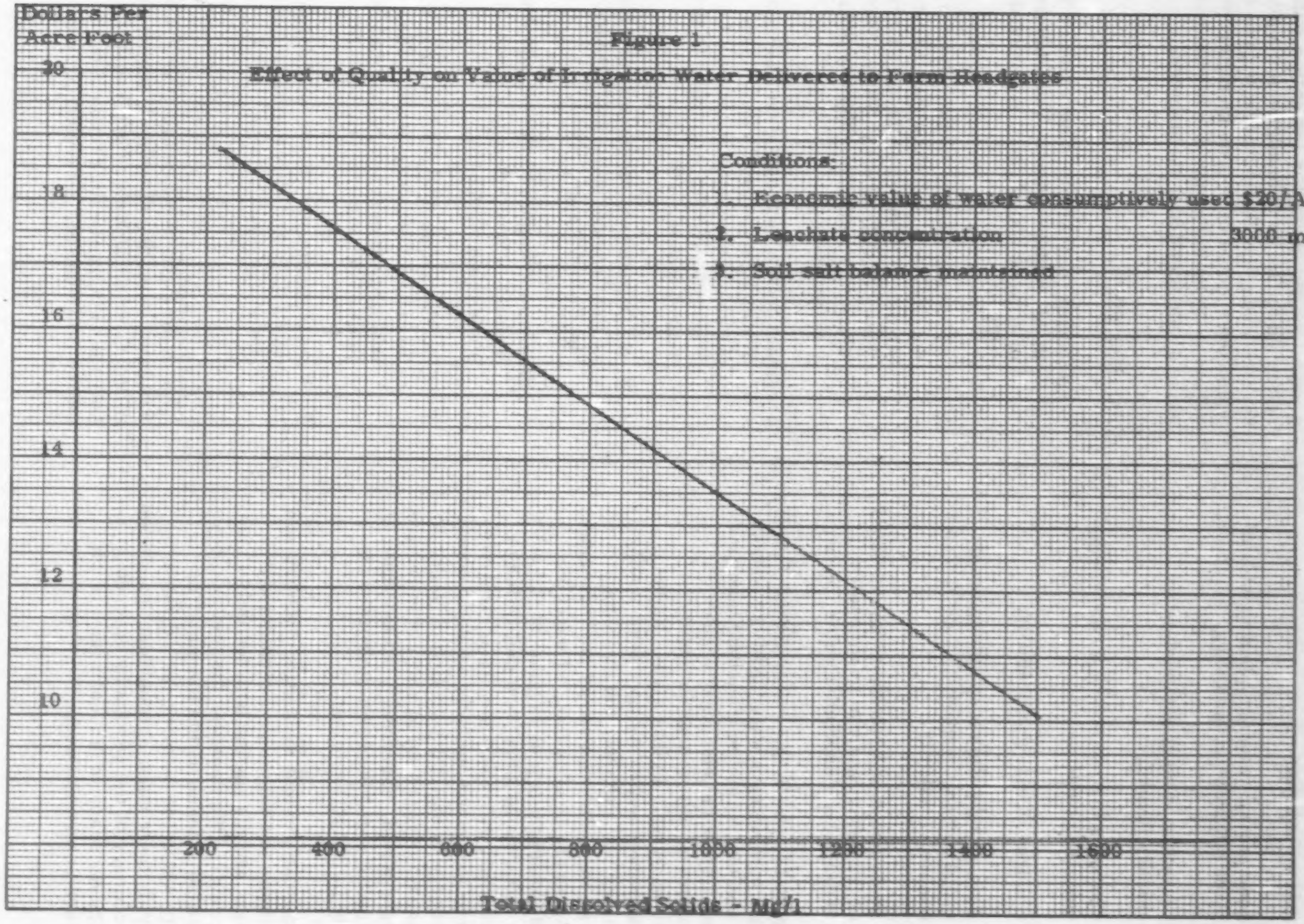

Figure 1

Effect of Quality on Value of Irrigation Water Delivered to Farm Headgates

Conditions:

1. Economic value of water consumptively used $20/Af
2. Leachate concentration 3000 mg/l
3. Soil salt balance maintained

EFFECTS OF IRRIGATION RETURN FLOWS

I IRRIGATION GEOGRAPHY

- A General
- B California

II FACTORS AFFECTING WATER QUALITY DURING IRRIGATION

- A Water Budget
  - 1 Rainfall and runoff
  - 2 Supplemental water
  - 3 Evaporation and transpiration
- B Salt Budget
  - 1 Salts in applied water
  - 2 Weathering
    - a Leaching
    - b Ion exchange
    - c Precipitation
  - 3 Applied chemicals
    - a Fertilizers
    - b Pesticides
- C Sediment Budget
  - 1 Erosion
  - 2 Filtration

III EFFECTS OF IRRIGATION RETURNS ON SURFACE WATERS

- A Physical
  - 1 The mixing problem
- B Chemical
  - 1 Concentrations of dissolved solids
  - 2 Character of dissolved solids
- C Biological
  - 1 Enrichment due to fertilizers
  - 2 Pesticides in waters and the food chain
- D Specific Areas
  - 1 Lower Colorado River
  - 2 Sacramento Valley, California
    - a A 55-acre rice field
    - b A 45,000-acre irrigation district
    - c The total 1,922,000 acres irrigated
  - 3 Imperial Valley, California
  - 4 San Joaquin Valley, California
    - a Predicted quantity and quality of drainage
    - b Alternative disposal schemes
  - 5 Klamath River Basin, California and Oregon

IV EFFECTS OF IRRIGATION ON GROUND WATERS

- A Salt Budget
  - 1 Favorable "salt balance" indicates leaching
- B Fertilizers

V ASPECTS OF IRRIGATION WITH WATERS RECLAIMED FROM SEWAGE AND INDUSTRIAL WASTES

Table 1

CHARACTERISTICS OF IRRIGATION RETURN FLOWS IN

SACRAMENTO VALLEY, CALIFORNIA, WY 1960-61[a]

Characteristic	Colusa Basin Drain		Reclamation District No. 108		Sacramento Slough	
	Max.	Min.	Max.	Min.	Max.	Min.
Specific conductance, μmhos	1,270	413	1,540	357	923	336
Temperature, ° F	83	46	-	-	84	46
D.O., mg/l	12.1	5.7	-	-	10.0	5.3
Per cent saturation	101	72	-	-	89	65
pH	7.6	7.5	-	-	7.6	7.4
Calcium, mg/l	48	20	-	-	50	24
Magnesium, mg/l	43	12	-	-	38	17
Sodium, mg/l	172	44	196	30	82	22
Potassium, mg/l	6.0	1.3	-	-	2.8	0.9
Carbonate	0	0	-	-	1	0
Bicarbonate	308	129	-	-	272	172
Sulfate	243	46	-	-	22	6.1
Chloride	113	21	133	19	157	17
Fluoride	0.4	0.2	-	-	0.2	0.1
Boron	0.52	0.18	0.99	0.20	1.3	0.2
Silica	22	12	-	-	32	20
TDS	792	247	-	-	554	201
Per cent Sodium	58	40	-	-	39	26
Hardness as $CaCO_3$						
Total mg/l	296	100	-	-	281	129
Noncarbonate mg/l	44	0	-	-	74	0
Total Nitrogen, mg/l	2.1	0.7	-	-	1.2	0.6
Total Phosphate, mg/l	0.8	0.4	-	-	0.7	0.3
Vitamin B_{12}, μμg/l	22		-	-	-	-
Sampling Interval	monthly		daily[b]		monthly	

(a) Adapted from "Sacramento River Water Pollution Survey," Bulletin No. 111. California Department of Water Resources, Sacramento (1962).

(b) Specific conductance at 25°C generally daily; other analyses based on composites at 2-15 day intervals between 4/15/60 and 12/30/60.

Table 2

CHARACTERISTICS OF IRRIGATION RETURN FLOWS IN

IMPERIAL VALLEY, CALIFORNIA[(a)]

Characteristic	SUPPLY		DRAINAGE					
	All-American Canal near Pilot Knoll		Alamo River near Calipatria		New River near Westmoreland		Whitewater River near Mecca	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Specific conductance, μmhos	1,353	981	4,545	2,230	5,743	2,155	4,902	3,134
Temperature, °F	88	65	90	48	92	48	87	54
D.O., mg/l	10.0	5.5	14.2	5.0	13.0	4.2	11.0	4.8
D.O., per cent saturation	119	71	131	59	136	55	112	60
pH	8.4	7.8	8.4	7.1	8.4	7.2	8.4	7.6
Calcium, mg/l	101	82	207	127	210	121	196	149
Magnesium, mg/l	41	26	100	55	100	57	52	42
Sodium, mg/l	132	93	546	296	918	332	884	428
Potassium, mg/l	6.2	4.0	15.6	7.5	19	7.6	17	11
Carbonate, mg/l	10	0	18	0	17	0	14	0
Bicarbonate, mg/l	177	154	366	118	452	140	384	256
Sulfate, mg/l	365	280	735	452	687	413	1,160	146
Chloride, mg/l	131	81	935	465	1,600	486	705	387
Fluoride, mg/l	0.72	0.4	1.2	0.0	0.86	0.40	4.0	1.2
Boron, mg/l	0.90	0.04	1.00	0.23	2.30	0.34	1.85	0.56
Silica, mg/l	20	5	38	10	23	8	23	15
TDS, mg/l	934	683	2,707	1,460	3,391	1,560	3,100	2,027
Per cent, Sodium	43	36	59	15	67	53	73	60
Hardness, as $CaCO_3$								
Total, mg/l	405	311	1,042	548	1,633	522	768	542
Noncarbonate, mg/l	265	180	7790	405	763	390	497	258
Period of Record[(b)]	1953-1961		1951-1961		1951-1961		1957-1961	

(a) Adapted from "Quality of Surface Waters in California, 1960-61," Bulletin No. 65-61, Vol. II, California Department of Water Resources, Sacramento (1964).

(b) Generally sampled every other month.

Table 3

CHARACTERISTICS OF IRRIGATION RETURN FLOWS IN SAN JOAQUIN VALLEY, CALIFORNIA[a]

	Estimated Concentration, mg/l	
Salts[b]	**1970**	**2020**
Calcium	330	120
Magnesium	180	40
Sodium	1600	720
Potassium	20	10
Carbonate	0	0
Bicarbonate	180	110
Sulfate	3100	650
Chloride	1200	900
Boron	10	3
TDS	6500	2500
Nutrients		
Total Nitrogen	21	21
Total Phosphate	0.15	0.15
Pesticides	0.001	0.001

(a) Adapted from "San Joaquin Valley Drainage Investigation. San Joaquin Master Drain." Bulletin No. 127, California Department of Water Resources. Sacramento (1965).

(b) Corresponding flows, in thousands of acre-feet per year, 1970 - 62.5; 1980 - 216.0; 1990 - 390.8; and 2000 - 497.4.

Table 4

PESTICIDES IN FAT OF FISH CAUGHT FROM IRRIGATION DRAINAGE WATERS[(a)]
(Concentrations in mg/kg)

Sample Identification	Sample Number (Length in inches)	DDT	DDD	DDE	Endrin	Dieldrin	Aldrin	BHC	Toxaphene
Channel									
Catfish from	1 (20.5)	45.5	164	269	Neg	ND	ND	ND	ND
Sutter Bypass,	2 (18.5)	10.8	112	92.5	Neg	ND	ND	ND	ND
California	3 (22)	23.2	71.4	88.2	.05	ND	ND	ND	ND
June 1964	4 (20)	78.0	212	124	.06	ND	ND	ND	ND
	5 (20.5)	15.6	76.8	40.0	Neg	ND	ND	ND	ND
	6 (20.5)	34.8	171.4	77.5	Neg	ND	ND	ND	ND
	7 (19.5)	7.0	20.0	23.4	Neg	ND	ND	ND	ND
White									
Catfish from	1 (20.4)	1,070	2,190	1,960	0.56	7.90	ND	ND	ND
Colusa Basin Drain,	2 (20.3)	455	758	1,392	Neg	9.27	ND	ND	ND
California	3 (12.5)	220	488	640	Neg	6.97	ND	ND	ND
July 1964	4 (11.1)	200	173	221	Neg	11.5	ND	ND	ND
	5 (20.4)	315	529	736	Neg	3.55	ND	ND	ND
	6 (b)	203	234	108	Neg	2.57	ND	ND	ND
Corvina from	1961	8	14	18	6	Neg	8	Trace	ND
Salton Sea,	1962	12	14	16	3	2	Neg	Neg	ND
California (c)	1963	3	3	3	Neg	Neg	Neg	Neg	2
	1964	25	17	33	Neg	Neg	Neg	Neg	Neg

(a) Based on personal communications from E. G. Hunt and Walter Thomsen, California Department of Fish and Game, Sacramento and Los Angeles, respectively (1965).

(b) Composite, lengths from 7.0 to 9.2 inches.

(c) Maximum values obtained for 3 samples per year, each of which consisted of composited fats from 5 fish.

ND No data
Neg None detected

SELECTED BIBLIOGRAPHY*

1 Breidenbach, A. W. and Lichtenberg, J.J. The Identification of DDT and Dieldrin in Rivers - A Report of the National Water Quality Network. Science, Vol. 141, p. 899. 1963.

2 Bureau of Reclamation. Reclamation Project Data. Department of the Interior, Bureau of Reclamation. 1961.

3 Cartier, F. W. Quality of Surface Waters in California, 1959, Southern California. Bull. No. 65-59, Part II, California Department of Water Resources, Sacramento. 1962.

4 Colorado River Board of California. Salinity Problems in the Lower Colorado River Area. State of California, Sacramento. 1962.

5 Eastman, P. W. Irrigation Drainage and Water Pollution. Paper presented at Annual Meeting, National Technical Task Committee on Industrial Wastes, San Francisco. 1964.

6 Gunnerson, C. G. Sacramento River Water Pollution Survey. Bull. No. 111. California Department of Water Resources, Sacramento. 1962.

7 Gunnerson, C. G. Sacramento River Water Pollution Survey. Hydrography, Hydrology, and Water Utilization. Bull. No. 111, App. A, California Department of Water Resources, Sacramento. 1962.

8 Gunnerson, C. G. Sacramento River Water Pollution Survey. Water Quality. Bull. No. 111, App. B, California Department of Water Resources, Sacramento. 1962.

9 Gunnerson, C. G. and Ritchie, E. A. Reclamation of Water from Sewage and Industrial Wastes in California, July 1, 1955-June 30, 1962. Bull. No. 68-62. California Department of Water Resources, Sacramento. 1963.

10 Hewitt, C. W., Nicolaus, A. F., Terry, W. L. and Seward, E. N. Feasibility of Reclamation of Water from Wastes in the Los Angeles Metropolitan Area. Bull. No. 80. California Department of Water Resources, Sacramento. 1961.

11 Johnson, O., Krog, N. and Poland, J. L. Pesticides. Part I. Insecticides, Miticides, Nematocides, and Rodenticides. Chemical Week, May 25, 1963, pp. 118-148. 1963.

12 Johnson, O., Krog, N. and Poland, J. L. Pesticides. Part II. Fungicides and Herbicides. Chemical Week, June 1, 1963, pp. 56-90. 1963.

13 Jopling, W. F. and Greenberg, A. E. Sacramento River Water Pollution Survey. Public Health Aspects. Bull. No. 111, App. D, California Dept. of Water Resources, Sacramento. 1962.

14 Lindholm, R. R. San Joaquin Valley Drainage Investigation, San Joaquin Master Drain. Preliminary Edition, Bull. No. 127, California Dept. of Water Resources, Sacramento. 1965.

15 Meron, A. and Ludwig, H. F. Salt Balances in Ground Water. Journ San. Engr. Div., Amer. Soc. Civ. Engrs. Vol. 89, No. SA3, pp. 41-61. 1963.

16 Morris, James M. Study of Boron in Citrus Packing Plant Waste Discharges. Tech. Rept., San Joaquin Valley Branch, California Dept. of Water Resources, Sacramento. 1961.

17 Nicholson, H. P. et al. Water Pollution by Insecticides in an Agricultural River Basin. I. Occurrence of Insecticides in River and Treated Municipal Water. Limnol. and Oceanog. Vol. 9, No. 3, pp. 310-317. 1964.

18 Quinn, K. R. Irrigation and Water Storage Districts in California: 1961. Bull. No. 21-61. California Dept. of Water Resources, Sacramento. 1963.

---

*Publications by L. V. Wilcox and co-workers at the USDA Salinity Laboratory, Riverside, California are listed in his presentation for this course.

19 Ritchie, E. A. Lower San Joaquin Valley Water Quality Investigation. (Includes Appendix by L. D. Doneen, Water Quality in Relation to Soil and Crop Production). Bull. No. 89, California Dept. of Water Resources, Sacramento. 1960.

20 Sylvester, R. O. Quality and Significance of Irrigation Return Flows. Jour. Irrig. and Drain. Div. Amer. Soc. Civil Engrs. Vol. 89, No. IR3, pp. 1-27. 1963.

21 Walker, Boyd W., Editor. The Ecology of the Salton Sea, California, in Relation to the Sportsfishery. Fish Bulletin No. 113, California Dept. of Fish and Game, Sacramento. 1961.

22 White, S. H. Quality of Surface Waters in California, 1961, Southern California. Bull. No. 65-61, Vol. II, California Dept. of Water Resources, Sacramento. 1964.

23 Willits, D. B. Water Quality and Water Quality Problems, Venture County. Bull. No. 75, California Dept. of Water Resources, Sacramento. 1959.

24 Willits, D. B. and McCullough, C. A. Salt Balance in Ground-Water Reservoirs. Trans. Amer. Soc. Civ. Engrs. Vol. 124, pp. 224-235. 1959.

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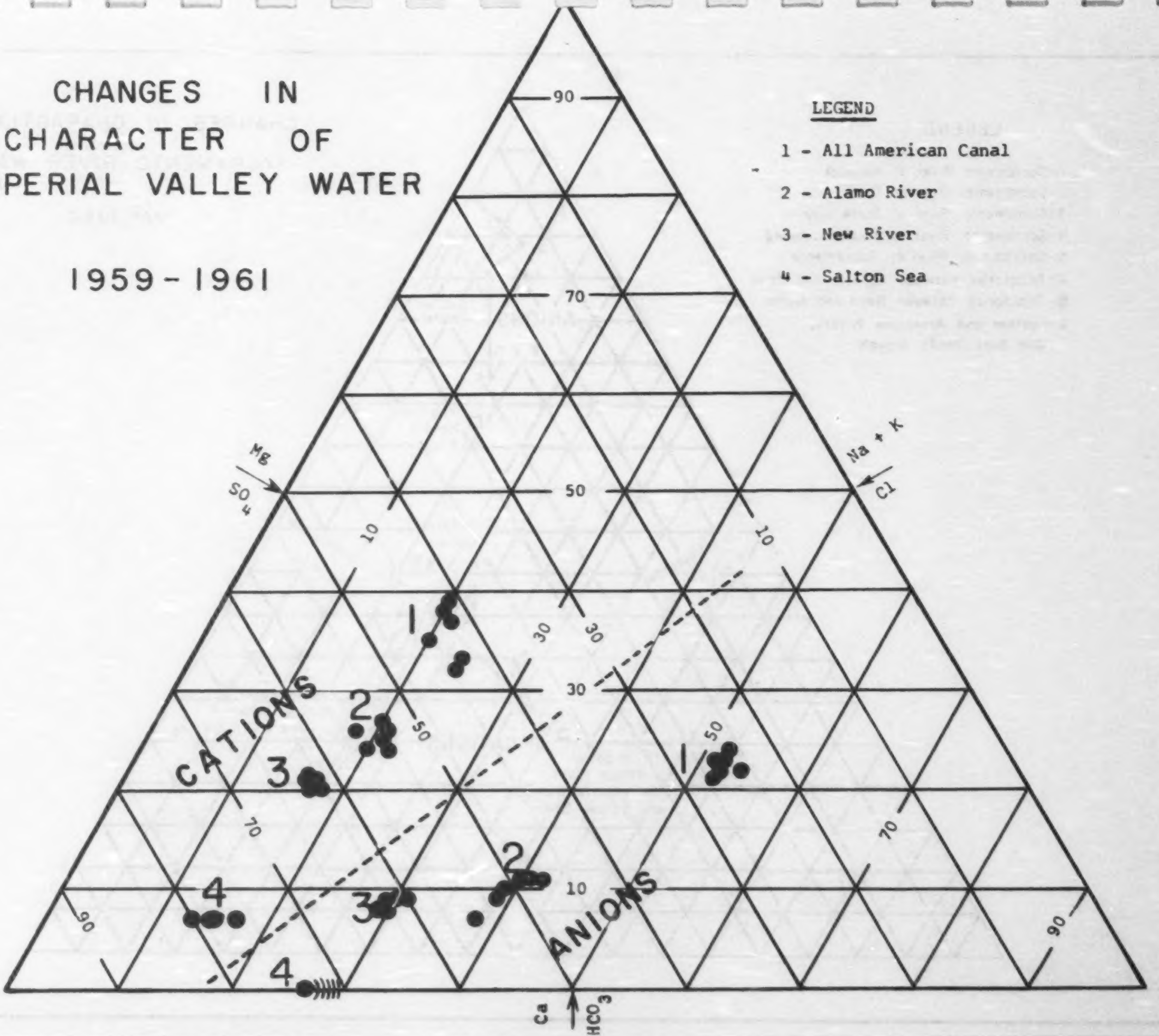
CHANGES IN CHARACTER OF IMPERIAL VALLEY WATER

1959 - 1961

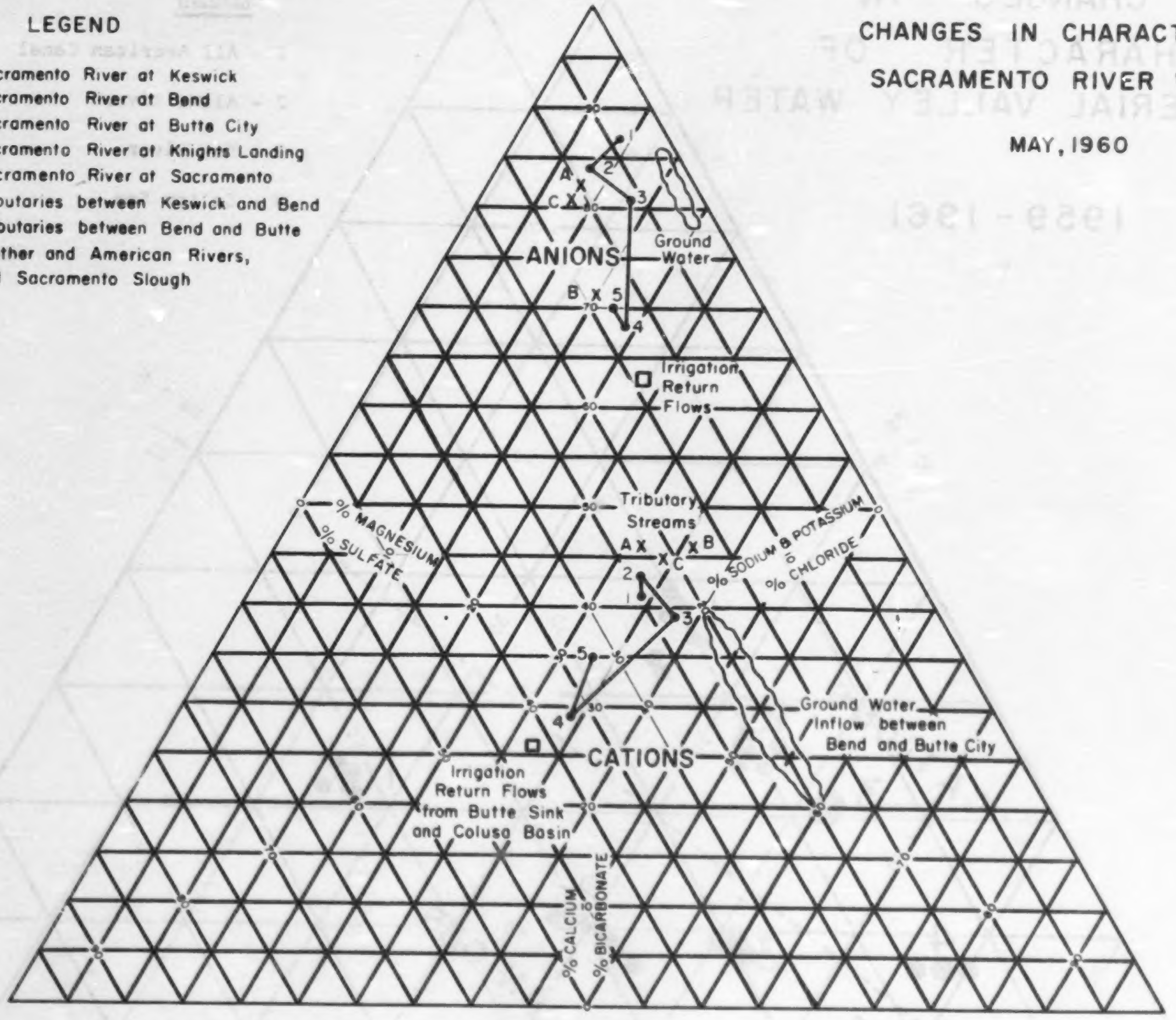


CHANGES IN CHARACTER OF SACRAMENTO RIVER WATER

MAY, 1960

LEGEND

1-Sacramento River at Keswick
2-Sacramento River at Bend
3-Sacramento River at Butte City
4-Sacramento River at Knights Landing
5-Sacramento River at Sacramento
A-Tributaries between Keswick and Bend
B-Tributaries between Bend and Butte
C-Feather and American Rivers,
and Sacramento Slough



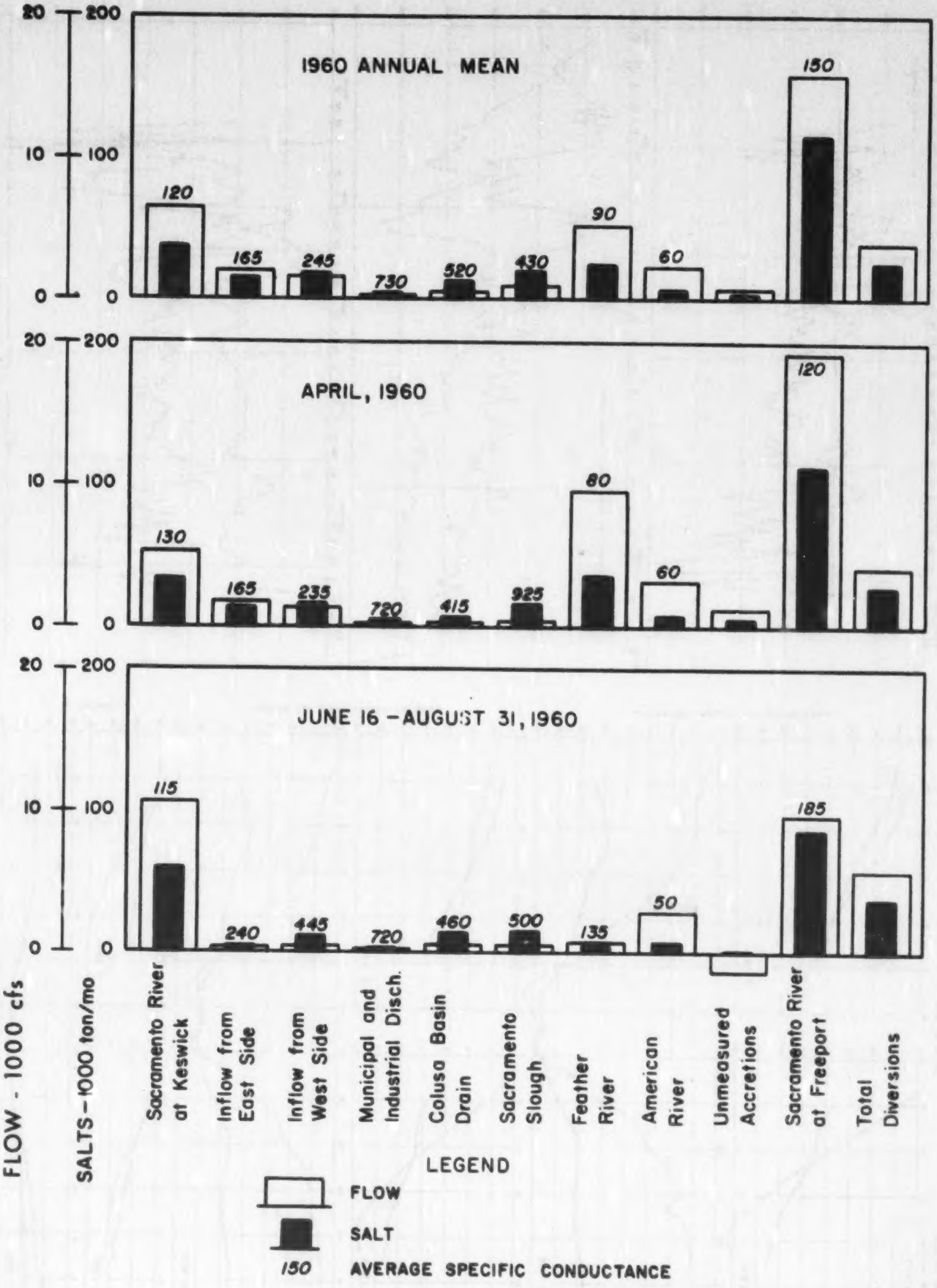


Figure 36. AVERAGE FLOWS AND TONS OF SALT TRIBUTARY TO SACRAMENTO RIVER, 1960

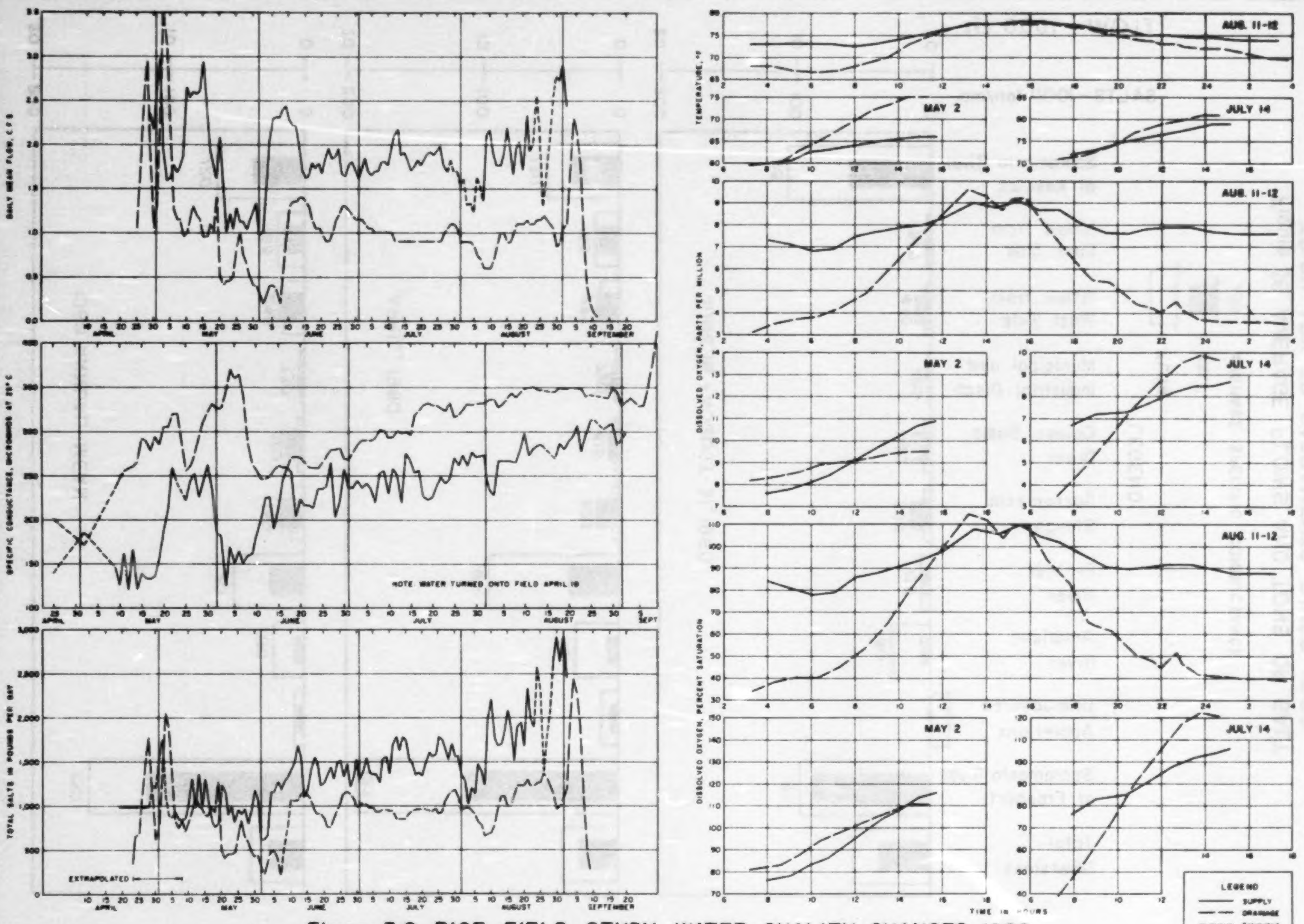


Figure 3.2. RICE FIELD STUDY - WATER QUALITY CHANGES 1960

Outline Number

WATER QUALITY MANAGEMENT ROLE OF INDUSTRIAL USERS

The Challenge, The Issues, The Problems 21

How Industries Organize and Operate to Manage Water Quality

The Pulp, Paper and Paperboard Industry

The Oil Refining Industry

The Chemical and Petrochemical Industries 22-C

The Iron and Steel Industry

"THE CHALLENGE, THE ISSUES, THE PROBLEMS"

I THE CHALLENGE - ELIMINATION OF WATER POLLUTION

A Control of Waste Discharges

B Installation of Facilities

- 1 Control at source
- 2 Low flow augmentation

C Operation of Facilities

- 1 Monitoring of effluents
- 2 Maintenance of equipment

II THE ISSUES

A What Is Pollution?

- 1 Historical
- 2 State and Federal laws

B Standards on Interstate Waters

C Jurisdiction

- 1 Local
- 2 State
- 3 Interstate
- 4 Federal

D Economic Justification

- 1 Values which cannot be expressed in terms of the market place.

III THE PROBLEMS

A People - Competent trained people to plan, to analyze, to research, to engineer, and to operate

- 1 The Federal effort
- 2 State effort
- 3 Industrial effort

B The Financial Problem

- 1 Relationship of water pollution control to other needs
- 2 The involvement of the Federal Government

C The Technical Problems

- 1 Quality - cost relationship
- 2 Development of alternatives

IV SUMMATION

A What?

B How?

C Who?

This outline was prepared for the Training Program by Thomas J. Powers, Industrial Program Advisor, Public Health Service, Division of Water Supply and Pollution Control, Washington, D. C.

HOW INDUSTRIES ORGANIZE AND OPERATE TO MANAGE WATER POLLUTION
THE CHEMICAL AND PETROCHEMICAL INDUSTRIES

The chemical industry is interested in operating at the highest efficiency. Since raw materials are one of the principal cost factors, the industry is interested in minimizing waste of all sorts.

At the local plant level, good housekeeping and the collection of leakage are necessary to good material utilization. Confinement and recycle to process are the first goals. Waste recovery is designed and built into the productive unit.

On the total plant scale, overall plant waste treatment is designed by the engineering department in consultation with experts in the waste treatment field, to prevent the adverse effect of accidental spillage--and for treatment of diluted waste material. Responsibility for the successful operation of waste treatment facilities is handled by a qualified individual who reports directly to the plant manager. But the plant manager has the ultimate responsibility for successful pollution abatement.

At the division and corporate levels, top level men with operating experience have the continuous responsibility for the coordination of pollution abatement activities. One of them inspects local plant facilities and serves on association committees for pollution abatement; hence he is able to provide information to the local operations on advancements in the art. He is also responsible for keeping top management advised of progress being made.

When additional waste treatment facilities are required for the plant, requests for the new appropriations are made through the normal chain of approvals, with final approval being granted by the corporate appropriations or finance committee.

Interest of the chemical industry in self-regulatory efforts can be documented by a 1962 survey conducted by MCA: 125 chemical manufacturing companies operated 875 plants showing a total capital expenditure in water pollution abatement of $263 million for waste control facilities, with operating cost estimated at $40 million a year. An additional capital investment of $69 million will have been made within the next few years. Approximately $5.5 million a year is being expended on water pollution abatement research.

There are about 13,500 chemical plants today. It is a dynamic industry faced with stringent competition from foreign chemical companies for world markets, yet it is striving to make steady progress in the abatement of pollution.

Better methods for handling and disposal of chemical wastes are desired. Government research programs, supplementing those of industry, and carried through the pilot plant stages, would be helpful in making progress at an accelerated rate. Favorable tax considerations for the installation and operation of pollution abatement facilities would be an incentive to utilize newer methods of waste disposal developed through research.

The chemical industry is interested in being a good neighbor. It expected to make steady progress in achieving improvement in the environment in which it operates, while providing a livelihood for its workers and improved products for the public.

This outline was prepared for the Training Program by Edward J. Fox, Vice President, Union Carbide Corporation, 777-14th Street, N.W. Washington, D. C.

Outline Number

MAN INFLUENCES WATER QUALITY - DIRECT WASTE DISCHARGES

Effects of Pollution on Aquatic Life 23

Land Runoff and How it Influences Water Quality 24

Bacteriological Considerations of Wastewater Discharges

Biological Treatment Technology and Its Impact on Water Quality 26

EFFECTS OF POLLUTION ON AQUATIC LIFE

I INTRODUCTION

A The effluent from any given industrial plant may be combined with municipal sewage, and/or wastes from other industries. This may occur in sewerage system or in a natural stream.*

1 Toxic wastes may inhibit biota or treatment plant as well as life in receiving stream.

2 Organic wastes may simply increase sewage type load on plant and stream.

3 Above effects may be reinforced or neutralized by other industrial wastes.

B The general overall character of a body of water may be subtly changed over a period of time.

II The principle of limiting factors (see Figure 1) deals with the response of organisms to various factors in the environment.

A Liebig's Law of the Minimum states that the distribution of a species may be limited by one or more essential environmental factors which occur in minimal quantities.

B Shelford on the other hand pointed out in his Law of Tolerance that there are also maximum values of most environmental factors which can be tolerated. In between these two extremes there are ranges which may be called "optimum" for factors useful to the organism.

C Purely deleterious factors on the other hand have a maximum tolerable value, but no optimum (see Figure 2). The range between the maximum concentration (greater than zero) which kills no organism and the minimum concentration which kills all organisms is known as the "critical range".

D These principles apply to all aquatic life whether in a stream or in some treatment plant. They are the basis for the control or regulation of biological conditions.

III INDIRECT TOXICITY: MODIFICATION OF THE ENVIRONMENT WHICH AFFECT AQUATIC LIFE

A Deposition of inert precipitates and silt tends to smother bottom organisms. Materials that may have this result are such as silt or sand from erosion due to poor agricultural practices, rock flour or tailings from mining or quarry operations, coal washings, sawdust and debris from lumbering, insoluble precipitates or complexes from chemical industries.

1 Vulnerable organisms include important fish foods such as insect larvae and snails; also fish eggs, bottom living algae such as diatoms, and many others.

2 Physical injury to delicate membranes of eyes, and gills may also result.

3 Inert suspended materials and dyes reduce light penetration, suppress photosynthesis and hence biological productivity. They also prevent game fish and other predators from seeing their prey, thereby reducing the efficiency of food utilization.

C Wastes of significant heat content may change the "climate" of a stream. This may be higher or lower than normal.

---

*The word "stream" may herein be interpreted in most cases to mean "river," "lake", "estuary," etc., if desired.

1 Abnormally low summer temperatures may prevent the reproduction of some of the typical inhabitants, on the other hand colder water forms such as trout may be enabled to survive.

2 Abnormally high winter temperatures may encourage too rapid development of some species, thus for example, causing the too early emergence of some insect followed by its death from normal winter air temperatures. Southern forms may also invade more northerly waters, sometimes leading to a year-round nuisance from flying swarms of adults such as caddis flies.

3 Artificially produced high temperatures, however, lack dependability. It is discouraging for organisms to spend six days in summer temperatures in January, only to freeze to death over the weekend because no one warned them that the plant would shut down !

4 Excessively high summer temperatures, even for a few hours once a year, probably represent the greatest temperture danger. Some species of fish can adjust to temperatures approaching 100°F, if the change takes place slowly. Each species however, has some maximum temperature above which it cannot survive. (Fig. 1)

a Quick temperature changes are fatal at much lower values.

b Lack of oxygen due to low solubility at high temperatures or from an increase in the rate of the BOD, also contributes greatly to high temperature mortalities.

D Oxygen consuming wastes kill by depleting the free dissolved oxygen resources.

1 Amount present, rather than percentage of saturation, is most significant in most cases.

2 Minimum amounts rather than averages are most critical.

a Any species can survive something less than the optimum concentration of DO for a limited period of time. There is, however, some concentration for any given temperature, which will eventually result in the death of that species. Let us call this the "critical" DO.

b As the DO falls below the critical concentration, survival time eventually drops to zero.

c The absolute values of these thresholds vary with the species and other

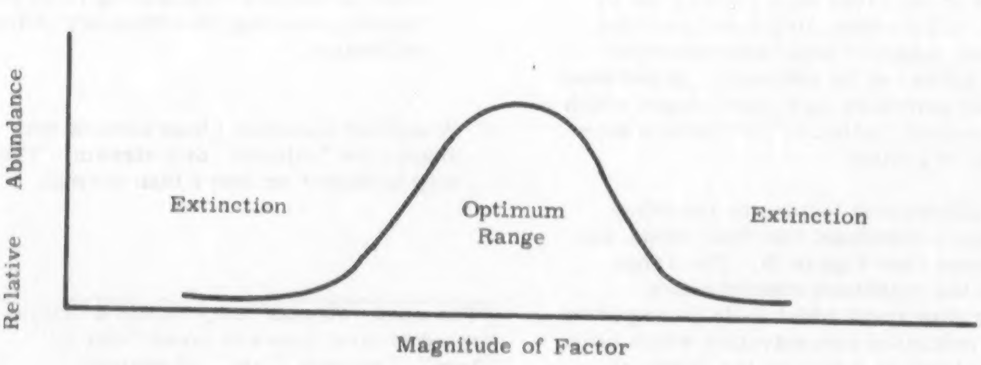


Figure 1- Shelford's Law or Toleration

factors, 5 ppm is often listed as a minimum permissible value to maintain a well rounded health population of fishes on a year-round basis.

3 Low oxygen tensions may also increase the toxicity of certain chemicals.

IV POLLUTION WHICH RENDERS FISH UNUSABLE OR INTERFERES WITH THEIR CAPTURE

A Radioactivity at levels currently found in our waters has not been observed to adversely affect aquatic life itself. It may however, be taken up with food materials and render fish or fishery products unusable.

1 Radioactive nuclides (forms of chemicals) are taken up by the plants (predominantly algae) in the processes of photosynthesis and other types of protoplasmic synthesis. There is no selection between nuclides on the basis of radioactivity.

2 As the chemicals originally assimilated by the algae are "eaten up the food chain" (from algae to invertebrates to small fish to large fish to man and other predators) their radioactivity moves along with them.

3 Thus radioactivity is acquired by fishes essentially through food, and scarcely at all by direct assimilation or absorption.

4 Plankton feeding organisms such as herrings, oysters, and clams acquire radioactivity directly from the algae on which they feed. Since they concentrate this food from large volumes of water, they may be much "hotter" than the surrounding water itself.

B Fish may be repelled or driven out of an area by obnoxious chemicals. This may simply result in their scarcity or absence from a given locale, or it may prevent their swimming up a river to spawn. In case the species would soon disappear and be lost to the community.

C Color, odor, oil, floating scum, bacterial slimes, and other such materials tend to discourage sport fishing and interfere with gear used by commercial fisheries.

D Sublethal concentrations of chemicals such as phenol, benzene oil, 2-4-D, etc., may impart on unpleasant taste to fish flesh, even when present in very dilute concentrations. This is nearly as detrimental to the fisheries as a complete kill, and of course applies to shellfish as well as fin fish.

V DIRECT TOXICITY: AFFECTS THE ORGANISM ITSELF

Fish kills are often the result of direct toxicity. If this is sufficiently potent to kill at once, or within a few days, it is called acute, and is often observed as a "fish kill". Action that may require weeks or months to be effective may be referred to as low-level, cumulative, or chronic toxicity, and is more often observed as simply a reduction of productivity: "Fishin' ain't what it used to be." Examples of chemicals often believed to be involved include: acids, alkalines, ammonia, chlorine, cyanides, metals, phenols, solvents, sulfides, synthetic organic chemicals, oil field brines, pesticides, herbicides, detergents and others.

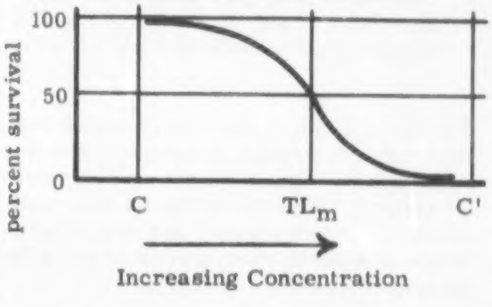


Figure 2 - General relationship of toxicity to survival. C maximum concentration at which no fish die, C' minimum concentration at which all die. TL_m, median tolerance limit (concentration tolerable to 50% of the population).

A Acute toxicity may be so broadly effective that many forms of life are affected at one time, or it may be highly selective. It may result from a low concentration of a highly toxic material or a high concentration of a relatively less toxic material.

1 It is frequently encountered as a "slug" resulting from a dump or spill, followed by normal, relatively non-toxic conditions as the mass of water containing the poison flows on downstream.

2 Acute toxicity can be evaluated by means of the toxicity bioassay technique.

B Chronic or low-level toxicity may change the entire population balance.

1 Susceptible species die off, thereby permitting tolerant species to fluorish for lack of competition.

2 Food organisms may be killed off so that fish die or move out of the area.

3 Weakened individuals are more susceptible to attack by parasites and disease, such as the aquatic fungus Saprolegnia.

4 Reproductive potential may be altered, Eggs or fry may or may not be more susceptible to toxic substances than adults.

5 The result may be a slow and subtle alteration of the characteristics of a stream over an extended period of time.

C The specific physiological mechanisms involved are infinite in variety and but little known. Included are such processes as enzyme inhibition as in the case with some of the pesticides, and over stimulation of mucous membranes of the gills, leading to death by suffocation.

D Very little can be learned at the present time from the autopsy of dead fish. If specimens can be observed dying, behavior as death approaches may be significant and should be reported. Specimens should be quick frozen and rushed to the nearest competent fisheries laboratory.

REFERENCES

1 Cairns, J. Jr., "Effects of Heat on Fish", Industrial Wastes 5:180-183, 1956.

2 Ellis, M. M., "Detection and Measurement of Stream Pollution", Bull. 22, U. S. Bur. Fish: also, Bull. Bur. Fish, 48:365-437, 1937.

3 Ettinger, M. B., et. al., "Critical Review of the Literature of 1955 on Sewage, Waste Treatment, and Water Pollution", Sewage and Ind. Wastes, 28:595-636, 707-764, 1956.

4 Foster, R. F., and Davis, J. J., "The Accumulation of Radioactive Substances in Aquatic Forms", No. A/Conf. 8/P/280, U. S. A. International Conference on Peaceful Uses of Atomic Energy, pp 1-7, 1955.

5 Ibid, "Aquatic Life Water Quality Criteria", Second Progress Report, Aquatic Life Advisory Committee, Sewage and Ind. Wastes 28:678-690, 1956.

6 Ingram, W. M., and Tarzwell, C. M., "Selected Bibliography of Publications Relating to Undesirable Effects Upon Aquatic Life by Algicides, Insecticides, Weedicides", PHS Publication No. 400, P.H. Bibliographic Series No. 13, June 1, 1954.

7 Ingram, W. M., and Towne, W. W., "Stream Life Below Industrial Outfalls", Public Health Reports, 74:1059-1070, 1959.

8 Ohio River Valley Water Sanitation Commission, "Procedures for the Investigation of Fish Kills", Aquatic Life Advisory Committee, 1956.

9 Tarzwell, C. M., and Gaufin, R. R. "Some Important Biological Effects of Pollution Often Disregarded in Stream Surveys". In Proceedings, 8th Annual Industrial Waste Conference, pp 295-316. 1953.

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LAND RUNOFF AND HOW IT INFLUENCES WATER QUALITY

I RAINFALL

A Relatively Generous, but Unevenly Distributed.

B Ranges From Virtually None to 150 Inches Annually, Averaging About 30.

C General in Some Areas, Highly Localized in Others.

D Storm May Wet Only Part of Community; however Tendency For Point Rainfall (Amount and Frequency) To Equal Areal Average.

E Rates Decrease With Increasing Rainfall Duration Periods. For Example (Cincinnati for 1 Year and for 50 Year Return Periods):

Rainfall Duration Period	Rate Rainfall 1 yr. Return-in/hr	Rate Rainfall 50 yr. Return-in/hr
5 min.	3.94	9.40
10 min.	3.18	8.60
15 min.	2.55	7.42
30 min.	1.65	5.20
60 min.	1.02	2.60
2 hr.	0.61	1.51
24 hr.	0.093	0.21

F Very High Rates Occur at Infrequent Intervals (Return Periods). Example (Cincinnati, for 5 Minute and 10 Minute Durations):

Return Period Yrs.	Rate Rainfall 5 min. dur-in/hr	Rate Rainfall 2 hr. dur-in/hr
1	3.94	0.61
2	4.51	0.72
5	5.50	0.90
10	6.38	1.14
25	7.38	1.34
50	9.40	1.51

G Rainfall rate expectancy for various duration periods and return periods may be calculated from local records as follows:

$T = \frac{M + 1}{N}$ where M = yrs. of record,

N = order number of rates listed in descending values, and T = return period. For example:

Order Number (N)	Rate Rainfall 5 min. dur - in/hr
1	9.72
2	7.32
3	7.32
4	6.60
5	6.48
6	6.31
7	6.23
etc.	etc.

Determine 10 yr., 5 minute rainfall rate from a 52-year record.

$$10 = \frac{52 + 1}{N} \qquad N = \frac{53}{10} = 5.3$$

$\therefore$ for N = 5.3, rate = 6.45 in/hr

H Rainfall frequency, duration, rate and amount are variously used in combination with other physical and with biochemical data to provide the basis for the hydraulic design for stormwater and combined sewers and for estimating constituent contributions in rainfall itself.

I Constituents in rainfall are demonstrated in the following analysis of rainfall from a 0.35-inch rainstorm July 12, 1964, at Cincinnati, Ohio:

Constituent	Concentration	Constituent	Concentration
pH	4.2 (mg/l)	NO_2-N	0.0 (mg/l)
Alk	0.0 (mg/l)	NO_3-N	0.4 (mg/l)
Total Solids	6.0 (mg/l)	NH_3-N	0.4 (mg/l)
Volatile Solids	3.6 (mg/l)	Org-N	0.8 (mg/l)
COD	3.3 (mg/l)	Total PO_4-PO_4	0.26 (mg/l)

II LAND RUNOFF

A Urban Environment

1 Land use

a 11,500 sewered communities in 50 states.

b Community areas range from < 0.5 to 454 sq. mi.

c Aggregate area, 43,100 sq. mi., or about 1.2 percent of U.S.

d Runoff coefficients may range from 0.05 for lawns, gardens and parks to over 0.90 for roofs, streets, and other solidly paved surfaces. Design areas are made up of composites of these land use elements.

e For example:

A residential-light commercial type area tributary to a storm sewer has 37 percent in roofs, streets and parking lots and the remainder in lawns, gardens and parks.

A city block may be occupied well over 50 percent in impervious surfaces.

2 Sewer Systems

a Separate type - has independent sanitary sewer system and storm sewer system.

b Separate systems were particularly attractive for small communities which could sewer the sanitary sewage and use road ditches for storm water drainage.

c "Combined" type - a common collection system for sewage and storm water. An interceptor diverts dry weather flow (sewage and infiltration) to the treatment plant. During wet weather the interceptor may divert several times the dry weather volume of the mixture to treatment. The rest, possibly 100 or 200 times or more, overflows to watercourses.

d "Combined" systems were simpler, cheaper and adequate for cities years ago when disposal without treatment was practiced.

e Of 11,500 community systems 79 percent are of the "separate" type (mostly smaller communities), and 17 percent are of the "combined" or a mixture of the two (mostly large and old communities).

3 Stormwater runoff

a Quantity is calculated by several methods - "rational" method probably predominates: $Q = CIA$, where C = runoff coefficient, I = rainfall rate (inches/hour is equivalent to cfs/acre) and A = drainage area in acres. The rainfall rate selected is that corresponding to a particular return period and a duration period equal to the concentration time at the point under consideration.

b Runoff coefficient increases with storm intensity and with duration.

c Examples of runoff coefficients:

Type District	Runoff Coefficient
Mercantile	0.70 - 0.95
Commercial	0.60 - 0.85
Industrial	0.55 - 0.80
Residential (Apartments)	0.5 - 0.7
Residential (Single & Double Dwellings)	0.25 - 0.6
Parks	0.25
Undeveloped areas	0.05 - 0.25

d Using a 15-minute concentration time, 0.50 runoff coefficient and rainfall rate (for 1 yr. return and 15 minute duration) of 2.55 inches/hour, which is equal to 2.55 cfs/acre, the flow per acre would be: (0.50)(2.55)(1) = 1.28 cfs. For comparison, a residential area sewage discharge at a population density of 10/acre would be about (10)(100)(1/7.48)(1/86,400) = 0.00155 cfs. In this case the stormwater runoff amounts to some 800 times the sewage flow at this peak runoff rate.

e An example of the quality of stormwater runoff can be provided from PHS study of a residential-light commercial area:

Constituent		Range*	Mean*
Turbidity		30 - 1,000 (Units)	170
Color		10 - 380	81
pH		5.3 - 8.7	7.5
		(mg/l)	
Alkalinity		10 - 210	59
Hardness (as $CaCO_3$)	Ca	24 - 200	63
	Mg	2 - 46	15
	Total	29 - 240	78
Chloride		3 - 35	12
SS		5 - 1,200	210
VSS		1 - 290	53
COD		20 - 610	99
BOD		2 - 84	19
Nitrogen (as N)	NO_2	0.02 - 0.2	0.05
	NO_3	0.1 - 1.5	0.4
	NH_3	0.1 - 1.9	0.6
	Org	0.2 - 4.8	1.7
PO_4 (total soluble as PO_4)		0.07 - 4.3	0.8

f Bacterial counts in stormwater runoff samples from a residential-light commercial urban area:

	Counts Exceeded in Designated Percent of Samples (Colonies/100 ml)		
	90%	50%	10%
Coliforms	2,900	58,000	460,000
Fecal Coli	500	10,900	76,000
Fecal Strep	4,900	20,500	110,000

g Comparison of stormwater runoff loads*and sanitary sewage loads (lb/yr/acre):

Constituent	Storm-water Runoff	Sanitary Sewage (raw)**	Storm / Sanitary in %
SS	730	540	140
VSS	160	360	44
COD	240	960	25
BOD	33	540	6
PO_4	2.5	27	9
Total N	8.9	81	11

---

*Period July 1962 through Septermer 1963, excluding January and February.

**From a residential-light commercial urban area.

h The significance of stormwater BOD, for example, equal to 6 percent of the raw sanitary sewage load in the residential - light commercial area abovementioned becomes more apparent where the need for a high degree of sewage treatment is visualized. If 90 percent removal of BOD is realized the stormwater runoff load now represents 60 percent of the sewage treatment plant effluent BOD. This is for a relatively clean type of land use. Densely populated and industrial urban areas probably produce more highly polluted stormwater runoffs.

i Study of stream water quality indicate that coliform bacteria counts vary with turbidity which in turn varies nearly directly with stream flow supporting the conclusion that much of the bacterial load derives from surface wash.

j Nutrient losses

k Pesticides

4 Combined Sewer Overflows

a Amounts and flow patterns comparable to stormwater runoff. Interceptors generally designed to divert 1 1/2 to 5 times dry weather flow volume of the wet weather mixture of sewage and stormwater. Custom tailoring of some systems to attempt local relief - reduce or prevent overflow at critical point by diverting to another point of overflow.

b Combined sewer hydraulics poor for dry weather sewage flows - stranding solids, odors, nuisance.

c Separation - complete? - partial? - none?

d Claims overflows amount to as much as 95 percent of the sanitary sewage during storms.

e "----about 1/3 of the city's annual production of sewage solids overflowed without treatment although only 2 to 3 percent of the sewage volume actually overflowed---"

f Scarcity of factual information on quality of combined sewer overflows. Example of combined sewer overflow quality:

Constituent	Concentration	Constituent	Concentration
pH	7.1	Sand	76 mg/l
Chloride	619 mg/l	DO	6.9 mg/l
TS	400 mg/l	Oil and Grease	33 mg/l
VS	144 mg/l	BOD	59 mg/l
SS	203 mg/l		

g Localized nature of storm sewer or combined sewer systems - 30 cities supplying information indicated numbers of overflow points to vary from 1 to 420 per city.

B Rural Environment

1 Land use

a Tilled

b Wooded

c Other

d Highway

2 Stormwater runoff

a Runoff influenced by land use and management within uses - USDA water and soil conservation studies and practices.

b Preliminary PHS data - runoff/rainfall factors on five small agricultural watersheds varied from 0.11 to 0.33 for a 2.21-inch rainstorm and from 0.20 to 0.56 for a 5.09-inch rainstorm.

c The following is an example of runoff water quality from one storm on one of the agricultural watersheds under study by the USDA and PHS at Coshocton, Ohio:

Constituent	Concentration	Constituent	Concentration
	(units)		(mg/l)
Turbidity	90	SS	56
Color	260	VSS	31
pH	7.7	NO_2-N	0.1
		NO_3-N	4.9
	(mg/l)		
Alkalinity	100	NH_3-N	0.4
Ca	73	Org. -N	7.5
		T. hyd. PO_4^-	2.7
Hardness (as $CaCO_3$) Mg	63	PO_4	
Tot.	136		(colonies/100 ml)
Chloride	28	Coliforms	19,000
COD	159	Fecal coli	340,000
BOD	23	Fecal strep	1,300
TS	392		
			(ng/l)
VS	193	Tot. org. Cl^-	248
		Lindane (possib.)	32
		2,4-D Ester (possib.)	141

d Significance of particular constituents.

e Constituent runoff unit loads.

C Comments on:

1 Urbanization

2 Studies past and present

3 Study needs

4 Controls

REFERENCES

1 Huff, F. A. Relation Between Point and Areal Rainfall Frequencies. Bulletin American Meterological Society, 37, 243. 1956.

2 Sanderson, Earl E. The Climatic Factors of Ohio's Water Resources. Bulletin 15, Division of Water, Ohio Department of Natural Resources, Columbus, Ohio. 1950.

3 Weibel, S. R., Anderson, R. J. and Woodward, R. L. Urban Land Runoff As A Factor in Stream Pollution. JWPCF, 36, 914. 1964.

4 American Sewerage Practice, Part I, Design of Sewers. Metcalf and Eddy, McGraw-Hill Book Co., New York. 1928.

5 Kansas River Basin Water Pollution Investigation. U. S. Public Health Service, Cincinnati, Ohio. 1949.

6 Pollutional Effects of Stormwater and Overflows from Combined Sewer Systems. HEW, Public Health Service Publication No. 1246. 1964.

7 Water Supply and Waste Water Disposal. Fair and Geyer, John Wiley & Sons, New York. 1954.

This outline was prepared for the Training Program by Samuel R. Weibel, Sanitary Engineer Director, Engineering Section, Basic and Applied Science Branch, Division of Water Supply and Pollution Control, SEC.

BIOLOGICAL TREATMENT TECHNOLOGY AND ITS IMPACT ON WATER QUALITY

I Wastewater treatment may remove 90 to 95% of the oxygen demand and solids from intercepted connections. Few cities maintain 90 to 95% collection.

A In one example, a reconstruction survey revealed a treated flow of 65 m. g. d. with an estimated 15 to 20 m. g. d. of raw waste discharged to the river via overloaded combined sewer diversion points.

B Inspection, coordination among departments and maintenance frequently are spotty for connections, lift stations, bypasses, and other interceptor appurtenances.

II Industry makes more durable synthetics, more potent specialty drugs and chemicals and more effective economic poisons in larger production centers. All contribute wastewater to established biological treatment units.

A Chemicals, steel and paper have been the largest water-using industries since about 1960. Each contribute different and varied problems that can be overcome with appropriate treatment control.

B Biodegradability may vary from very good to negligible values.

C Treatability varies with the possibilities for neutralization, precipitation, conversion to cell mass, mechanical entrapment, sorption, volatility, settleability and other factors.

D More comprehensive analysis are required to determine the extent of removal during treatment.

E Treatment control of air, time, temperature and food to solids ratios are likely to accentuate pollutant removal. Flocculation, adsorption and alternate physicochemical treatment may be required when biological treatment is inadequate.

F If it can be measured, it can be removed, providing the nuisance justifies the cost.

III Solids deposition invariably occurs when water velocity is low enough. Pollution hastens the deposition or filling process by increasing the biological residues and possibly the water-carried silt.

A Assimilation of nutrients tends to form cell mass which may be oxidized, lysed, and reconstituted many times, eventually forming humis-like residuals.

B Deposited sludge tends to become anaerobic which results in increased hydrolysis and release of lysed nutrients. The lysed products are likely to be more available than the sludge from which they were formed.

C Sludge accumulates in localized areas. A 1-day deposit may not contribute enough lysed products to cause a nuisance; a 30-day deposit may be objectionable.

IV Nutrients include all substances that are essential for metabolic growth.

A Nutritional status is related to oxidation stage, biota, conditions, and availability.

B Each nutrient is concentration-dependent. Some optimum concentration will stimulate growth; some higher concentration may be inhibitive or germicidal.

C Metabolic processes derive energy for growth and maintenance via nutrient conversion. A net energy release is a necessary criteria.

D Nutrients rarely are nutritionally balanced, hence certain excess items may create a nuisance while a deficiency of one essential may inhibit conversion.

E Nutrients may be recycled many times through a cycle of growth, death, and lysis. Each cycle results in a loss of material as CO_2, water or other oxidation products.

1 CO_2 is an oxidation product of aerobic metabolism but a raw material for photosynthesis.

2 Theoretically, nutrients can be recycled indefinitely but practically they become unavailable by conversion to relatively inert humis, sludge removal, volatilization, conversion to inert chemicals such as nitrogen, or isolation by cover or transport.

This outline was prepared for the Training Program by F. J. Ludzack, Chemist, Chemistry & Physics Section, Basic & Applied Sciences Branch, Water Supply and Pollution Control, SEC.

MAN'S INFLUENCE ON WATER QUALITY THROUGH IMPOUNDMENTS

	Outline Number
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The Significance of Eutrophication	
Practical Implications of Current Impoundment Work for Comprehensive Management	29
Water Quality in Impoundments - Experiences of T.V.A.	

MAN'S INFLUENCE ON WATER QUALITY THROUGH IMPOUNDMENTS

OVERALL PICTURE OF IMPOUNDMENT PROBLEMS

I Many free-flowing rivers are becoming a series of impoundments.

II Impounding water influences water quality by changing detention time, surface to volume ratio, velocity, and so forth.

III Examples of Detrimental Influences

- A Dissolution of iron and manganese
- B Loss of dissolved oxygen in lower waters
- C Production of hydrogen sulfide
- D Development of nuisance organisms
- E Chance for evaporation

IV Examples of Beneficial Influences

- A Reduction in turbidity
- B Oxidation of organics
- C Reduction in bacterial populations
- D Smoothing out of slug concentrations

V Our research in the Basic and Applied Sciences Branch is designed to understand all aspects of impoundment behavior better.

This outline was prepared for the Training Program by James M. Symons, Research Public Health Engineer, Engineering Section, Basic and Applied Sciences Branch, Division of Water Supply and Pollution Control, SEC.

PRACTICAL IMPLICATIONS OF CURRENT IMPOUNDMENT WORK FOR COMPREHENSIVE MANAGEMENT

A Provides Information

  Clarifies Problems

  Discloses Interrelationships

B Implies Solutions

  Direct Activities

  Modifications

C Stimulates Action

  Provides Alternatives

  Breaks Down Inertia

This outline was prepared for the Training Program by John E. McLean, Operations Officer, Water Resources Studies, Technical Services Branch, Division of Water Supply and Pollution Control, Washington, D. C.

	Outline Number
BIOCIDES (PESTICIDES) IN THE ENVIRONMENT	
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POTENTIAL LONG TERM HEALTH IMPACT OF PESTICIDES IN THE ENVIRONMENT

Multiple environmental chemicals of which pesticides are a class are known structurally but others especially the metabolites their composition and structure are unknown. They provide a constant subthreshold or micro insult to target organs or cells. An appreciation of this stress and sophistication in this field of research is limited among scientists including toxicologists.(1, 2) Availability of bioassay procedures for delineation of the subtle responses at cell level from micro stresses limits demonstration of acute effects as the precursor to chronic effects elaborated ultimately in chronic disease of undefined etiology. More recently, however, research emphasis has been placed in this field of toxicology to assess the latent effects of pesticides on present and future generations through careful studies on carcinogenesis, mutagenesis and teratogenesis.

Many drugs, food additives and contaminants utilize common detoxification pathways. Recently, there has been evidence that additive toxic effects may result from combination of several insecticides or synergistic action on drug metabolizing enzyme systems in mammals.(3, 4, 5, 6) A tenfold increase in toxicity for malathion for example has been noted by addition of EPN (ethyl-P-nitrophenyl benzenethiophosphate) using 25 parts of malathion to 1 part of EPN. Dietary levels of 25 ppm of EPN and 50 ppm of malathion caused an inhibition of cholinesterase greater than strictly additive effects. Even at lower level of 3 ppm of EPN and 8 ppm of malathion potentiated toxicity in dogs was noted in erythrocyte cholinesterase measurements. Detoxification of malathion is also inhibited by Dipterex, TOTP (tri-o-tolyl phosphate) and chorthion. Hence, chronic administration of organophorphorus compounds profoundly affects the metabolism and detoxification of other compounds.

The organochlorine compounds effect on drug metabolizing enzyme systems has received limited study. DDT and chlordane has been shown to have a stimulatory effect on hepatic microsomal enzymes responsible for oxidation of hexobarbital, aminopyrine and chlorpromazine. Recent work has also shown that rats on diets containing 10 ppm of DDT store less vitamin A in their livers than normal rats. The mechanism as to detoxification enzyme system involved here is unknown.

The organochlorine compounds induce neurohormonal and liver changes as recognizable toxic reactions. They are capable of increasing the plasma levels of corticorterone, catecholamine and norepinephrine. These compounds are associated with fat metabolism. What long-term action these potentiated effects may have in respect to induction of disease has not yet been assessed. It is maintained by oncologists that the destruction of liver cells resulting in rapid multiplication to offset the hepatotoxic action presents a greater opportunity for cancerigenic agents to exert their effect. It has been shown in experimental work with rainbow trout that DDT produces liver damage at 80 ppm levels in diet after 20 months feeding and liver cancer results.(7)

Organophosphate compounds have been shown to produce significant behavioral effects and whereas there may not be a dramatic effect in adults, effects may be produced in the young or immature that persist into adulthood. Massive brain lesions are the classic example.(8, 9, 10) Chronic exposure of immature organisms to low concentrations may then produce behavioral effects detectable in adults. In addition, the exposure of pregnant females to compounds having these behavioral effects may have a pronounced effect on the offspring.

Elucidation of the structure of DNA and a clearer understanding of the mechanism of action of viruses and environmental chemicals in the alteration of this cellular constituent has provided a basis for appreciation of the potentiation of biological responses reflected in cell proliferation (cancer) and gene mutation (mutagenesis). Several compounds are described that are in the pesticide class that have these properties.

Adverse effects of carcinogens must be subtle if the cell is to survive. Weak carcinogens may kill some cells but for the most part they may only have sublethal effects. The chief concern is for these weak carcinogens or mutagens which may require a long interval to develop to the point of clinical recognition. This period between exposure and ultimate development of a disease state may be a fraction of life span and sometimes this is greater than one half of one's life span.(11)

Certain components of the population are so genetically constituted that they may respond differently if not fatally to environmental chemicals.(12, 13) A case of such poisoning is the compound napthalene which is involved in detoxification through the enzyme system glucose-6-phosphate dehydrogenase.

In order to delineate the long-term latent microstress from environmental stress agents such as pesticides, well-designed biostatistical surveys or epidemiological studies on large population groups by retrospective or prospective procedures are required to provide the data and information on induction of disease. The Public Health Service has started such projects in 10 areas in this country with this objective in mind.

REFERENCES

1 Shubik, P. and Sice, G. Chemical Carcinogenesis as a Chronic Toxicity Test: A Review. Cancer Res. 16 728-742. 1956.

2 Kraybill, H. F. Role of Subliminal Pharmacology Programs in Support of Carcinogenesis Research. Pub. Health Repts. 77 No. 9, 745-751. 1962.

3 Frawley, J. P., Fuyat, H. N., Hagan, E. C. and Jones, W. I. J. Pharmacol. 119 147. 1957.

4 Hart, L. G. and Fonts, J. R. Pharmacologist 5 230. 1963.

5 Dubois, K. P. Advances in Pest Control Research 4 117. 1961.

6 Rosenberg, P. and Cron, J. Proc. Soc. Exp. Biol. and Med. 97 836. 1958.

7 Halver, J. E., Johnson, C. L. and Ashley, L. M. Dietary Carcinogens Induce Fish Hepatoma. Fed. Proc. 21 390. 1962.

8 Hebb, D. O. The Organization of Behavior. New York: Wiley. 1949.

9 Furchtgott, E. Psychol. Bulletin 53 321. 1956.

10 Werboff, J. and Gottlieb, J. S. Obstetr. Gynecol Survey 18 420. 1963.

11 Homburger, F. The Physiopathology of Cancer. Second edition. Hoebler Harper Pub. Co., New York, N. Y. 924. 1959.

12 Kraybill, H. F. The Pesticide Program of the Public Health Service. J. Am. Publ. Health Assoc. (in press) 1965. Presented at A.P.H.A. Meeting, New York City, October 5-9. 1964.

13 Childs, B. and Young, W. J. Genetic Variations in Man. Am. Jour. of Med. 34 663-73. 1963.

This outline was prepared for the Training Program by H. F. Kraybill, Ph. D., Pesticide Program Officer, Public Health Service, BSS (EH) Washington, D. C.

ANALYTICAL CHEMISTRY OF PESTICIDES IN WATER

I Analysis of pesticides in water is based on developments in other fields of residue analysis, but it has requirements peculiar to the field of water.

A The analyst must be prepared to encounter any pesticide that is manufactured or used, in any combination.

1 Methods that are specific for a single compound are not practical.

2 Methods used must be capable of application without any prior knowledge of what pesticides to expect.

B Water pollution analyses require extreme sensitivity, at least 1000 times more sensitive than the usual permissible levels in agricultural products.

1 On the other hand, the sample is seldom limited in quantity.

C Pesticide analytical methods must be proof against interferences by all other organic chemicals that are water pollutants.

II Available analytical methods for pesticides in water cover a wide range of basic principles, utility, and reliable specificity.

A Bioassay methods (fish or insects) show the cumulative effect of possible mixtures and are not specific, but they are logically related to the important effects of pesticides.

B Methods specific for individual compounds - usually colorimetric procedures - are rarely used.

C Analysis for functional groups or specific elements is somewhat more valuable, e.g., organic, P, Cl, or S.

D Infrared methods have the longest successful history of application to water problems. They also provide the surest identification.

E Methods based on controlled separation processes are the most powerful combination of sensitivity and specificity.

1 Separations are based on various forms of chromatography.

2 Specific tests can be combined with the separation process, e.g., color tests on paper chromatograms.

III Gas chromatography is the basis for the largest proportion of today's methods of pesticide analysis.

A The method is applied best to chlorinated pesticides, but it is often suitable for the phosphorus insecticides.

B The power of gas chromatography in analysis is based on the combination of features:

1 Extreme sensitivity - sample actually used in an analysis may be 1 nanogram or less.

2 Separation power - nothing equals its ability to separate a complex mixture including several pesticides and many extraneous organics.

3 Speed - the analysis by gas chromatography takes less than 1 hour; complex preliminary processing is usually unnecessary.

4 Non-destructive - in some cases the chromatographed compound can be recovered pure for other analytical confirmation.

C Special detection procedures are combined with gas chromatography in pesticide analysis.

1 Electron capture detectors are extremely sensitive to common chlorinated insecticides.

2 Microcoulometric detectors are specific for the sulfur in thiophosphorus insecticides.

IV There are special problems of interferences arising in water pollution and related samples.

A Other organic pollutants in the water sample cause interference in routine methods because they accompany and simulate or obscure the pesticides.

1 Some affect the selective detectors of gas chromatography.

2 The proportion of extraneous organics to pesticides is always very high.

B Other analytical problems arise because water studies require so much more sensitivity than other problems. Errors that are inherent are only important in water analyses.

V Future progress in pesticide analysis in the environment is certain, if only because the need is so great.

A Current methods do not include general methods for important classes of pesticides, e.g., weed killers and carbamate insecticides.

1 New classes are constantly under development and being introduced.

B The general methods are not sufficiently specific. In a water analysis, it is often impossible to make a firm identification when the insecticide identity is suspected.

1 A very recent addition to the armament is Beroza's "p" factor.

This outline was prepared for the Training Program by A.A. Rosen, Chemist, Chemistry and Physics Section, Basic & Applied Sciences Branch, Division of Water Supply and Pollution Control, SEC.

SAMPLING OF THE AQUATIC ENVIRONMENT FOR PESTICIDES

I THE AQUATIC ENVIRONMENT

Pesticides may be distributed or concentrated in various parts of the environment. Therefore, sampling of the following may be important: water, dissolved and suspended solids, sediment, plankton, attached plant or animal life, fish, birds, and some of the invertebrate animals.

II SIGNIFICANCE OF SAMPLES

A Water

1 **Pesticides are dissolved in water in minute amounts.**

2 **Pesticides may be adsorbed by suspended solids in raw water.**

B Sediment and Mud

1 Transport

2 **Accumulation of pesticides on bottom of streams.**

C Plankton

1 **Transport of pesticides**

2 Concentration

D Attached Algae and Bottom Fauna -

Uptake or concentration.

E Fish

1 **Presence in various tissues**

2 **Tolerance relationship to levels of pesticides.**

3 Concentration

F Invertebrate Animals

1 **Pesticide levels**

2 Concentration

3 **Significance as part of food chain.**

4 **Significance as food for human consumption.**

III SAMPLING METHODS AND AIDS

A Sample Containers

1 **Every precaution should be taken to prevent contamination of sampling devices and containers by pesticides or interferring materials.**

2 **Glass or metal containers required.**

3 **Plastic materials to be avoided. (Teflon is satisfactory).**

4 **Cleansing of containers (new or old) with pesticide solvent is good practice.**

B Carbon Adsorption Method

1 **Carbon cartridge.**

a **Dimension 3 inches by 18 inches pyrex.**

b **Carbon types**

1) **Sizes - 4.5 inches of 4 X 10 mesh on each end, and 9 inches of 30 mesh carbon between.**

2) **All fine carbon for low flow.**

c **Contamination precautions**

C Mud Samples

   1 Collection in glass or aluminum containers.

   2 Preservation by freezing

   3 Drying and extraction

D Plant or animal tissue

   1 Collection

   2 Packaging and identification

   3 Preservation by freezing (dry ice).

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PESTICIDES IN AQUATIC ECOLOGY

I Pesticides encompass a wide range of chemicals and the range of sensitivity of aquatic animals to different types is over 1,000,000 times.

A Some pesticides are not acutely toxic at concentrations in the water exceeding their solubility.

B For fish, endrin is among the most toxic of chemicals known when dissolved in the water.

C The oral LD_{50} of many pesticides for fish is not especially low.

D Chronic effects of pesticides on aquatic life have been little studied.

1 Some carbamates are known to damage the lipoid cover of nerve cell processes. This damage may be permanent.

2 Organic phosphorus compounds inhibit enzymes that are involved in nerve impulse transport.

3 Chlorinated hydrocarbon insecticides accumulate in lipoid tissue. The young of fish are sometimes killed when the last of the embryonic oil is absorbed.

II Some pesticides are very stable, even in aquatic environments, and may persist for years.

III Many aquatic animals accumulate very high concentrations of certain pesticides in tissues.

A Concentration factors of tissue over water range up to 10,000 times and probably more.

B Fish are known to accumulate tissue concentrations that make them unfit for human food, even though the water concentrations in which they lived never exceeded a few parts per trillion.

IV Metabolites and degradation products of some pesticides are more toxic than the parent material.

A Some bacterial degradation products of a herbicide are capable of incorporating in body protein.

B Biological systems convert aldrin to dieldrin and dieldrin is more toxic to most animals.

V The value of pesticides in pest control is unquestionable. The hazards are important and real. Great care is mandatory when their use is necessary.

There are few, if any, benefits of pesticidal use to aquatic life. Therefore, aesthetic and economic (including recreational) values must be the primary considerations when the damage of pesticides to aquatic life is evaluated.

This outline was prepared for the Training Program by Dr. D. I. Mount, Fisheries Research Biologist, Aquatic Biologist, Aquatic Biology Section, Basic and Applied Sciences Branch, Division of Water Supply and Pollution Control, SEC.

Outline Number

RECENT DEVELOPMENTS IN WATER AND WASTEWATER TREATMENT TECHNOLOGY

The Problem of Synthetic Organic Wastes 35

Susceptibility of Viruses in Treatment Technology

Advances in Coagulation Treatment Technology 37

Applied Engineering Research in Removal of Viruses and Persistent Organic Chemicals 38

Advanced Treatment of Wastewaters for Reuse 39

THE PROBLEM OF SYNTHETIC ORGANIC WASTES

I Sources of organic chemicals in water are varied and of differing complexity.(1)

A Natural pollutants, such as algae, actinomycetes, etc. contribute to organic pollution.

1 Tastes and odors associated with these materials are probably not merely a result of decomposition, but are closely associated with materials produced during the life cycle of the organisms and plants.

2 Discharge of nutrients in the form of phosphorus and nitrogen compounds from domestic or other wastes frequently stimulate the production of natural pollutants.

B Industrial wastes, due to the rate of population increase and industrial expansion, have made the problem of effective water treatment an acute one in many places.

1 The production of synthetic organic chemicals has risen steadily over the past years, representing many new and complex products - and of importance to us - new and complex wastes.

2 The ideal method of handling industrial waste is at its source.

a However, what is often considered good treatment, still results in materials present in sufficient quantities to affect the taste and odor of water.

b Many problems are caused by slug discharges, often accidental.

C Domestic wastes in various stages of treatment.

D Miscellaneous sources also contribute to the problem.

1 Wastes from private and commercial boats.

2 Chemicals applied to the land may be washed into streams.

3 Chemicals applied directly to water.

a Evaporation control

b Killing off rough fish

c Aquatic plant control

II Concentrations of organic chemicals in water, even in comparatively minor quantities may cause difficulties.

A Wastes may contain from a few mg/l to several hundred mg/l of organic contaminants.

B Surface waters may contain from a few µg/l of organics to several mg/l.

1 Some of the chemicals isolated from water, along with the concentrations which can be detected by odor, are:(2)

Substance	Concentration Detectable*, µg/l
Formaldehyde	50,000
Picolines	500 - 1,000
Phenolics	250 - 4,000
Xylenes	300 - 1,000
Refinery hydrocarbons	25 - 50
Petrochemical waste	15 - 100
Phenyl ether	13
Chlorinated phenolics	1 - 100

*Concentrations were determined by taking the median of 4-12 observations.

III The damaging effects of organics in water are becoming more apparent.

A Taste and odor in water is usually the first noticed effect from organics. This is a serious public relations and economic problem; it also may be a health problem.

B Organic contaminants may interfere with coagulation, damage ion exchangers, and create chlorine and carbon demand.

C In the stream they may have adverse effects on aquatic forms that support higher aquatic life, cause off-flavors in fish flesh, or have direct toxic effects on fish.

IV The methods of study employed in the collection and identification of organic chemicals in water involve physical and chemical methods and instrumental analysis.

A The comparatively small amounts of organic materials may be concentrated by adsorption on activated carbon.

1 This carbon is then extracted with appropriate organic solvents, the solvent extract is taken to dryness, the weighed extract is subjected to solubility group separation, and these individual groups may then be analyzed by various methods.

2 Employing the above method on Ohio River water, the following results were obtained:(3)

Chemical Group	% of Total	TOC in $\mu g/l$	Relative Odor Contribution
Water solubles	20	860	23
Ether and water insolubles	22	110	200
Neutral	14	3	4,670
Amine	4	575	7
Weak acid	8	645	12
Strong acid	6	365	16
Amphoteric	10	$5,000^+$	--
Loss	16	--	--

B Chemical separation and analyses may be accomplished by means of column chromatography, formation by derivatives, gas chromatography, infrared and ultraviolet spectroscopy, x-ray diffraction, etc.

1 Specific organic chemicals recovered from river and drinking waters by these methods include: synthetic detergents (ABS), phenylether, phenol, DDT, aldrin, o-nitrochlorobenzene, α-conedendrin, and xylene.

V Some of the types of problems that may be attributed to organic wastes, and more specifically to problems of taste and odor, may be represented by the following examples:

A By applying the previously mentioned carbon adsorption method, the odor potential of organic pollutants and the dilution necessary to reduce this odor potential to a barely perceptible level has been determined:(4)

Industry Source	Conc. Required for Detectable Odor µg/l		Dilution Factor	
	$CHCl_3$ Sol. Org.	Total Org.	$CHCl_3$ Sol. Org.	Total Org.
Brewery	770	1,400	14	86
Chemical	28	32	11,000	14,000
Corn Refining	1,000	3,600	1.4	2.1
Meat Packing	1,200	3,600	92	140
Metal Fabrication	890	1,600	2.8	4.8
Paint	390	1,000	69	98
Pharmaceutical	290	340	10	32
Refinery	84	510	780	760
Soap	900	1,800	640	350

B Of all the organic pollutants that can affect the taste and odor of drinking water, phenol has been the most extensively studied.

1 The potential sources of this chemical, both natural and synthetic, have been discussed.(5)

2 The course of chlorination of phenol, a common method of treatment in the water plant, has been shown to proceed by a process which starts with the pure compound (in itself relatively tasteless) and proceeds through strong-tasting intermediates to tasteless end products.(6)

C The effects of petrochemical wastes(7) on water quality are becoming increasingly important; it has been predicted that by 1970 the petrochemical production on a tonnage basis may be equal to 41% of all chemicals.

1 The three principal groups of petrochemicals are the paraffins, the naphthenes, and the aromatics. From these, over 200 basic products are manufactured, having thousands of subordinate uses.

2 Correspondingly, more than 100 identifiable compounds have been found in waste streams from petrochemical processes.

BIBLIOGRAPHY

1 Middleton, F. M. Taste and Odor Sources and Methods of Measurement. Taste and Odor Control Journal. 26:1. 1960.

2 Middleton, F. M., Rosen, A. A., and Burttschell, R. H. Taste and Odor Research Tools for Water Utilities. Jour. A. W. W. A. 50:21. 1958.

3 Anonymous. Objectionable Organic Contaminants in Water. San. Eng. Center Activ. Rep. No. 25, 1955.

4 Sproul, O. J., and Ryckman, D. W. The Significance of Trace Organics in Water Pollution. PCF 33:1188. 1961.

5 Hoak, R. D. The Causes of Tastes and Odors in Drinking Water. Water and Sewage Works. 104:243. 1957.

6 Burttschell, R. H., Rosen, A. A., Middleton, F. M., and Ettinger, M. B. Chlorine Derivatives of Phenol Causing Taste and Odor. Jour. A. W. W. A. 51:205. 1959.

7 Gloyna, E. F., and Malina, Jr., J. F. Petrochemical Wastes Effects on Water. Indus. Water & Wastes, 7: #5. 134. Sept. - Oct. 1962.

8 Baker, R. A. Problems of Tastes and Odors. WPCF. 33:1099. 1961.

This outline was prepared for the Training Program by R. L. Booth, Chemist, Chemistry and Physics Section, Basic and Applied Sciences Branch, Division of Water Supply and Pollution Control, SEC.

ADVANCES IN COAGULATION TREATMENT TECHNOLOGY

I NATURE OF THE COAGULATION PROCESS

A Coagulation vs. Flocculation.

B Desirable Characteristics of Floc.

C Physical and Chemical Mechanisms of Coagulation.

1 The electrical double layer of colloidal particles.

2 Chemical complex formation.

3 Mechanical entrapment by floc.

4 Mutual coagulation.

II VARIABLES WHICH AFFECT THE COAGULATION PROCESS

A Nature and Amount of Turbidity Present

B Coagulant and Coagulant Dosages

C pH

D Alkalinity

E Temperature

F Mixing of the Coagulant with the Water

G The Presence of Interfering Substances

1 Inability to obtain good coagulation with any reasonable amount of coagulant.

2 Excessive amount of coagulant required.

3 Weak floc which disintegrates and penetrates the filter media.

4 Floating floc.

5 Pretreatment required or additives necessary with the primary coagulant.

a Activated carbon

b Clay

c Oxidants

d pH adjustment

e Activated silica

f Organic polyelectrolytes

III COAGULATION EQUIPMENT

A Conventional

B Upflow Clarifiers

C Flocculation in Filters

IV CONTROL OF THE COAGULATION PROCESS

A Jar Test

B Electrophoretic Measurements

C Turbidity Monitors

V RESEARCH GOALS

REFERENCES

1 Mackrle, S. Mechanism of Coagulation in Water Treatment. J. San. Eng. Div. Proc. A.S.C.E. 88, SA 3, Part 1, 1. 1962.

2 Stumm, W. and Morgan, J.J. Chemical Aspects of Coagulation. JAWWA 54:971. 1962.

3 Packham, R. F. The Coagulation Process - A Review of Some Recent Investigations. Proc. Soc. for Water Treatment and Exams. 12:15. 1963.

4 Priesing, C. P. A Theory of Coagulation Useful for Design. Ind. Eng. Chem. 54:8, 38. 1962.

5 Erdei, J. F. Advances in Water Treatment. JAWWA 55:845. 1963.

6 Fair, G. M. and Gemmell, R. S. A Mathematical Model of Coagulation. J. Colloid. Sci. 19:360. 1964.

7 Cohen, J. M., Rourke, G. A. and Woodward, R. L. Natural and Synthetic Polyelectrolytes as Coagulant Aids. JAWWA 50:463. 1958.

8 Baylis, J. R., and Mrva, A. E. Use of Acid-Treated Sodium Silicate in Coagulation. JAWWA 55:1536. 1963.

9 Mueller, K. C. and Burbank, N. C., Jr. Effects of Polyelectrolyte Coagulant Aids on Removal of Missouri River Turbidity with Ferric Sulfate. JAWWA 56:333. 1964.

10 Garnell, M. A. Effects of a Polelectrolyte as a Filter Aid. JAWWA 55:597. 1963.

11 Conley, W. R. and Pitman, R. W. Innovations in Water Clarification. JAWWA 52:1319. 1960.

12 Robeck, G. G., Dostal, K. A. and Woodward, R. L. Studies of Modifications in Water Filtration. JAWWA 56:198. 1964.

13 Ives, K. J. Progress in Filtration. JAWWA 56:1225. 1964.

14 Cohen, J. M. Improved Jar Test Procedures. JAWWA 49:1425. 1957.

15 Riddick, T. M. Zeta Potential and Its Application to Difficult Waters. JAWWA 53:1007. 1961.

16 Black, A. P. and Smith, A. L. Determination of the Mobility of Colloidal Pesticides by Microelectrophoresis. JAWWA 54:926. 1962.

17 Bean, E. L., Campbell, S. J., and Anspach, F. R. Zeta Potential Measurements in the Control of Coagulation Chemical Doses. JAWWA 56:214. 1964.

This outline was prepared for the Training Program by Sidney A. Hannah, Chemist, Engineering Section, Basic & Applied Sciences Branch, Water Supply & Pollution Control, SEC.

APPLIED ENGINEERING RESEARCH IN REMOVAL OF VIRUSES AND PERSISTENT ORGANIC CHEMICALS

I BASIC PHILOSOPHY OF THE ENGINEERING RESEARCH PROGRAM

To apply a systems analysis approach to designing water and waste treatment plants and then to have the designs fit into a river basin management plan. To do this effectively it is necessary to understand the role of each of the unit processes and operations performed in treatment plants.

II METHODS FOR IMPLEMENTATION

In the last ten years, laboratory or bench-scale experiments have been combined with pilot plant operation at SEC so as to demonstrate the effectiveness of various water treatment processes to remove such things as virus, algae, spores, radioactive particles, pesticides, clay, and floc particles in general. These experiments have then been followed up with cooperative field testing at industrial and municipal plants so as to verify pilot plant conclusions. These studies have involved the testing of plant modifications such as media type and arrangement, filtration rates, and elimination of certain unit processes. The same pattern of study, namely, laboratory, pilot and on through a full-scale, has been used to develop design criteria for removing odorous and dissolved organic material.

We have tried to be responsive to the three principal problem areas: the fate and techniques for removing virus, ABS, and pesticides.

III RESULTS

A Virus and Other Particulate Removal

Pilot plants were used over a period of 3 years to treat turbid water from the Little Miami River and virus-spiked waters to test various suggested plant design modifications.

The principal findings indicated:

1 Two feet of clean, well-packed sand removed poliovirus from water that was flowing at less than 4 ft. per day, and the percentage removed gradually decreased until most of the organisms went through at rapid filtration rates.

2 When preceded by coagulation, a double-layered bed of coarse media made of 18 inches of coal (effective size 1.05 millimeters) on top of 6 inches of sand removed turbidity, coliform bacteria, poliovirus, or powered activated carbon as efficiently or better than a bed of coal or sand alone. Use of such a bed also extended filter runs.

3 With proper coagulation ahead of the filter, a filtration rate of 6 gallons per minute per square foot (gpm/sq ft) removed all test particles listed in (2) above as effectively as a 4- or 2-gpm/sq. ft. rate.

4 Adequate floc strength was more important in achieving clarity than a certain settleability when coarse media and high filtration rates were used. This strength was often obtained only by adding 5 to 20 ppm activated silica as a coagulant aid, or 0.05 to 0.2 ppm synthetic polyelectrolyte as a filter aid.

5 When the river water was relatively clear (< 25 units), the flocculation and sedimentation treatment were not necessary if coarse media were placed on top of the sand.

6 With this particular river water, the inclusion of flocculation and limited sedimentation extended filter runs and resulted in the production of better water during winter and flood conditions.

7 Poliovirus in clear water was more readily removed by beds of fresh, clean granular activated carbon than by sand. When carbon had been exhausted by a high loading of dissolved organic contaminants, however, it did not remove much more virus than a similar-sized sand or coal medium.

B Pesticide Removal

A literature review showed that the use and variety of pesticides are increasing, and their persistence in soil and water is cause for concern to the waterworks industry. Pilot plant and jar test studies were, therefore, conducted by using river water spiked with 1 to 10 μg, respectively, of six pesticides per liter to determine the removal efficiencies of various water treatment processes.

The accumulative removals shown in the attached table indicate that each part of a water plant may have some potential for reducing certain pesticides, and thus the following conclusions can be made:

1 DDT was easily removed by a combination of settling and coagulation followed by filtration. Lindane and parathion were not reduced significantly by these conventional processes.

2 Chlorine and potassium permanganate in the 1 to 5 mg/l concentration range did not reduce chlorinated hydrocarbons. These oxidants did convert parathion to a different, but more toxic compound.

3 At relatively large impractical concentrations, ozone did reduce the chlorinated hydrocarbons somewhat, but again the by-products formed and their toxicity are not known.

4 A powdered activated-carbon slurry greatly reduced all of the five pesticides tested in river water. Only 5 to 10 mg/l was needed to achieve 99 percent removal of parathion, but greater doses were necessary for similar removal of lindane, dieldrin, and endrin.

5 Fresh, granular activated-carbon beds were able to reduce pesticide concentrations to the detectable level of 0.01 μg/l.

6 Even when exhausted by the usual odor criterion, the carbon bed was able to remove a majority of an intermittent pesticide load.

C Taste and Odor and Organic Removal

Due to the inclusion of a new parameter, carbon chloroform extract (CCE), in the 1962 Drinking Water Standards, there has been an increased interest in the quantity of organic matter in raw and finished water. This change merely served to emphasize the need for the control of non-odorous organics as well as the usual odorous compounds. We have, therefore, been trying to characterize both and reduce organics in general with the use of activated carbon much as organisms in general are reduced by chlorination.

A series of small-scale experiments and a full-scale test were conducted to obtain granular carbon consumption data for removal of odorous and non-odorous organic material from Kanawha River water at the Nitro, West Virginia, Water Plant. The treatment at this plant included double aeration, chlorination, conventional coagulation, and sand filtration followed by two full-scale granular carbon beds, which were housed in rebuilt gravity sand filter structures. Criteria were developed for use in the design of a granular carbon system for Nitro.

The operation of the various carbon beds resulted in the following general conclusions:

1 Granular carbon reduced both the odorous and non-odorous organic material sufficiently to meet the recommended drinking water standards.

2 Standard size, 8- × 30-mesh, granular activated carbon beds were able to produce an odor-free water for as long as 26 days, depending upon the contact time and the raw water TO which varied from 300 to 1300.

3 A finer carbon, 20- × 50-mesh, produced an odor-free water for twice as long as the standard size carbon.

4 Within the tested range of physical and hydraulic conditions, a linear relationship was found between contact time and carbon performance.

5 When the TO was reduced to less than 3 the CCE was generally reduced to less than 200 µg/liter as measured with the modified monitor.

6 When the TO was reduced to less than 3 the COD was reduced to less than 7 mg/liter.

7 Of nine compounds frequently found in Kanawha River water, nearly all were removed to non-detectable levels during the entire period of satisfactory water production and all were reduced to non-detectable levels by relatively new carbon.

8 With a contact time of 7.5 minutes the expected carbon consumption for the winter months, when the organic load is relatively high, well range between 0.7 and 1.3 pounds per 1,000 gallons, depending upon carbon size and method of operation.

9 An operating cost of 200 dollars per day or 1.7 cents per pound of carbon reactivated was estimated for the winter months. This was based on a reactivation rate of 12,000 pounds per day for a 10 mgd plant.

10 The expected daily average operating cost for a 12-month period would be lower than that for the winter months because of the lower odor levels in the raw water during the rest of the year.

D ABS Removal

1 In soils

The results from many soil lysimeter studies indicate that soil systems can be made to degrade the newer synthetic organics as well as the usual COD components. Specifically these experiments have demonstrated the following:

a ABS in the effluent from a septic tank can be degraded from a level of 5 or 35 mg/l to less than 0.5 mg/l, if applied properly to certain unsaturated soils.

b The use of an S^{35}-tagged ABS in part of the ABS loading and a chemical material balance demonstrated that there was degradation as well as adsorption.

c Subsurface intermittent feeding on a daily basis provided an opportunity for aeration and caused aerobic organisms to thrive. Most sandy soils handled at least 0.5 to 1.0 fpd (0.15-0.3 m/day) of waste.

d Dissolved organics such as ABS or 2,4,5-T must be held up in the microbially active zone near the top. This was accomplished by a certain selection of soil and the accumulation of organic material originating from the sewage.

e The usual organisms found in sewage and soil were able to degrade ABS, 2,4,5-T, 2,4-D, or o-cresol if sufficient time was provided for them to adjust and handle new organics in the waste.

f Coliform organisms, odor, turbidity, and COD were usually greatly reduced and nitrification took place when the ABS was degraded below 0.5 mg/l.

g Subsequent work was published on optimum soil size, depth, and hydraulic load and pattern.

h Full-scale field tests with local officials are being conducted in Long Island and Wisconsin.

2 By conventional coagulation supplemented by activated carbon

Conventional water treatment does very little to reduce the ABS level. Both granular carbon beds and powdered carbon slurry techniques have been used to remove detergents in renovating waste water and cleaning up river water with such contaminants.

The granular carbon can be put in gravity or pressure vessels after the usual filtration but we have also demonstrated that certain granular carbons can be used effectively in the filtration as well as the adsorption process if they are placed on top of 6 to 8 inches of sand in the conventional gravity filter structure. Under this or any arrangement, the carbon needs to be reactivated or else replaced on a fairly frequent interval so there is still much to be done in working out optimum design and cost estimates.

This outline was prepared for the Training Program by Gordon G. Robeck, Chief, Engineering Section, Basic & Applied Sciences Branch, Water Supply and Pollution Control Training, SEC.

SUMMARY OF CUMULATIVE PESTICIDE REMOVAL IN PERCENT AT 10 μg/l LOAD

PESTICIDE / PROCESS	DDT	LINDANE	PARATHION	DIELDRIN	2, 4, 5-T ESTER	ENDRIN
CHLORINATION, 5 mg/l	<10	<10	75*	<10	<10	<10
COAGULATION 8 FILTRATION	98	<10	80	55	65	35
CARBON:						
SLURRY						
5 mg/l.	—	30	>99	75	80	80
10 mg/l.	—	55	>99	85	90	90
20 mg/l.	—	80	>99	92	95	94
BED @ 0.5 gpm/cu. ft.	>99	>99	>99	>99	>99	>99

*Ozidized to para-oxon, more toxic than parathion.

ADVANCED TREATMENT OF WASTEWATERS FOR REUSE

I INTRODUCTION

Much has been written over a period of many years about the need to control pollution. More recently there has been a rapid rise in interest in treating wastewaters for more direct and deliberate reuse. In some circumstances, control of pollution without any expected water reuse is the principal or only reason for waste treatment. Treatment ahead of ocean disposal generally represents such a case. On large rivers, wastewaters are treated to prevent nuisance conditions, and to protect health. Subsequent reuse of the water once used by the city may be inconsequential. On smaller rivers, however, the treated effluent of one city may make up a substantial portion of the water supply for a downstream user. In water-short areas a potential, often-overlooked source of additional water for industrial, agricultural, or even domestic needs is wastewater. The merits of reusing wastewater have to be weighed against the costs of alternative sources of supply. Treatment needs for reuse vary from "slight" to actually preparing a water equal to or even better than the original supply.

The Advanced Waste Treatment Research Program of the Public Health Service was begun in mid 1960 to develop new treatment technology for wastewaters with the more direct and deliberate use of the treated water in mind. Research on treatment of wastewater for reuse on an indefinite basis was directed by the 1961 amendments to the Water Pollution Control Act (Public Law 87-88). These amendments direct the Secretary of Health, Education, and Welfare "... to develop and demonstrate practical means of treating municipal sewage and other waterborne wastes to remove the maximum possible amounts of physical, chemical, and biological pollutants in order to restore and maintain the maximum amount of the Nation's water at a quality suitable for repeated reuse."

A Some Examples of Wastewater Reuse

1 Direct reuse of wastewater is not new. The Bethlehem Steel Company has successfully used sewage treatment plant effluent from Baltimore for many years. In the West and Southwest, crops, public parks, and golf courses have been supplied with water from treatment plants quite routinely at a number of locations. In most such cases, only moderate, if any, "advanced" treatment is applied. Slow sand filtration and chlorination has been utilized, for example. This direct reuse of effluents has taken place predominantly in California, Texas, Utah, Nevada, New Mexico, and Arizona.

2 Recreational reuse of treated wastewaters has been dramatically demonstrated with the construction and operation of a series of lakes used for boating and fishing at Santee, California. After activated sludge treatment, the city's effluent is held in a lagoon for 30 days and is then chlorinated, spread into shallow infiltration basins from whence it travels through one-half mile of a natural sand and gravel formation. The water rises again to the surface flows through a series of artificial lakes which have become quite popular for waterbased recreation. Studies are now being made at Lancaster, California with similar aims for providing recreational water from the community's waste flow.

3 At Whittier Narrows, near Los Angeles, California a 10 mgd water reclamation plant is in operation. The sole purpose of the plant is to recover water that would otherwise be lost to the sea. Waste treatment per se is not needed at this location. Here, raw municipal waste is collected by diverting a part

of the flow of a large trunk sewer. The waste is treated by the conventional primary sedimentation and activated sludge processes. Advanced treatment consists of foam separation following the secondary clarifiers to remove foam-causing impurities, chlorination, and finally spreading of the effluent on the ground for infiltration to the underground supply. The treated effluent is purchased by the Flood Control Authority. The underground aquifer serves all purposes, including domestic supply. At present, rerenovated water makes up less than 10 percent of the total underground flow. The Whittier Narrows plant discharges sludge and condensed foam back to the trunk sewer for ultimate ocean disposal.

4 At San Ramon Village, California activated sludge effluent is foamed to reduce the ABS content to an acceptable level. At Lake Tahoe advanced treatment by chemical flocculation to remove phosphates followed by filtration and activated carbon adsorption is in the planning stage to ensure that damage does not occur to this natural body of water. Many other communities are considering reuse of their wastewaters. These uses vary from irrigation and industrial supply to supplementing drinking supplies. While much of this type of reuse will occur in arid areas, advanced treatment will likely become popular even in the wetter areas of the country. The drought of 1963 brought to the attention of many mid-western plant operators the need to have periodic better treatment even in areas where dilution is normally adequate. Population increases will demand more adequate pollution control.

B Need for Advanced Waste Treatment Processes

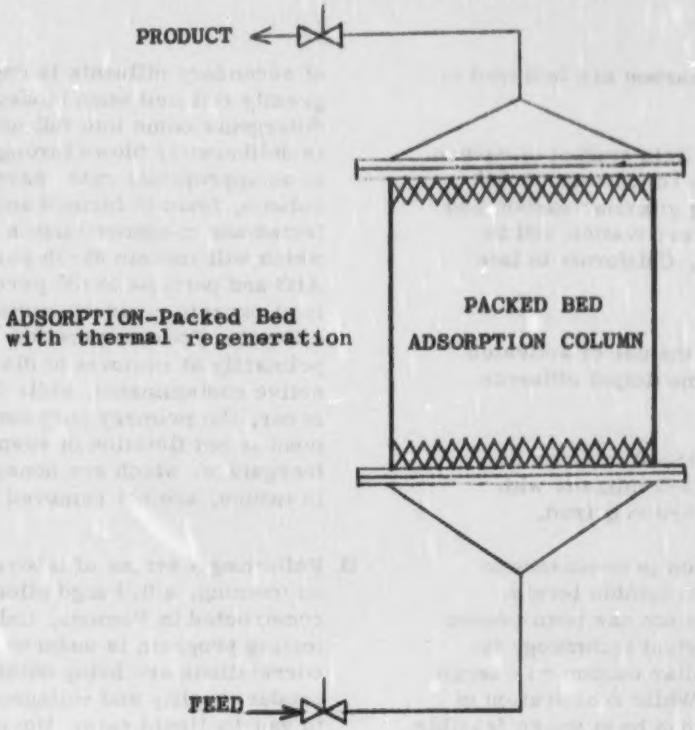
1 Our present day conventional waste treatment processes will continue to serve us well in the future as they have in the past. However, supplemental treatment will have to be provided to meet the growing pollution control needs and to prepare water for the many foreseeable reuse situations.

2 Our best conventional processes may achieve a 90 percent reduction in BOD and suspended solids and do a good job in reducing microbial contaminants. To go much beyond 90 percent treatment, new methods are needed. In addition, reuse requirements will make mandatory the removal of non-BOD organics and inorganics which are not removed at all by processes now in use. For example, in a recycle situation, inorganic salts would build up to intolerable levels after two or three uses. After use of water by a city and conventional treatment, organic materials of 50-100 ppm (measured as COD) and about 300 ppm of inorganic salts will have been added to the initial water supply. Many, but not all, water reuses will require negligible organic content and controlled inorganic content. How is this to be achieved?

C Technical Factors

1 From a technical standpoint, any quality water can be prepared from a wastewater. To control pollution and prepare water for reuse on a large volume basis for an acceptable cost is the real challenge. Additional treatment will cost more--but the product has more worth. The value of having clean water is difficult to assess in all circumstances but in any case, the positive value of such water cannot be questioned.

2 Since biological processes, as we now use them, leave residues of significance, it seems logical to investigate the potential of processes using chemical or physical principles of separation. The Advanced Waste Treatment Research Program has, by means of internal studies and negotiated contracts with industries, universities and private groups, investigated a number of possible separation techniques. Contractors, and their areas of investigation are listed. No "miracle method"



ADSORPTION-Packed Bed with thermal regeneration

is needed or expected. Rather, the job is to evaluate a variety of processes to determine their technical capabilities and cost. The overall process of treatment, the quality goals, the need for continuous or intermittent treatment, and myriad other factors determine the system of choice. Treatment applications need not be restricted to municipal wastewaters. Fundamentals will apply to any water requiring quality improvement--municipal wastes, industrial wastes or even raw supplies.

3 More positive and more flexible control of treatment is possible where physical or chemical processes are used as compared to biological treatments. Adsorption, foaming, oxidation and the like can be "turned off and on" with relative ease. This is of real importance since the highest levels of treatment for pollution control may only be needed intermittently. Costs, therefore, are significantly lowered if a process is applied only part-time.

4 The process descriptions that follow represent progress reports on the status of studies. Much more detail on these processes is available through detailed reports of the Advanced Waste Treatment Research Program. No firm cost figures for processes can be given at this time. Estimated costs are based on projections of data at hand and are subject to change.

II ADSORPTION

A Activated carbon is an effective adsorbent. Other materials are also adsorbent in nature but none tested were as effective as carbon for many classes of organic substances. When municipal activated sludge effluents are passed through beds of granular carbon or when powdered carbon is slurried with the effluent and subsequently removed, from 70 to 95 percent of the COD-bearing organic materials are eliminated. The carbon treated effluent is clear and nonfoaming. The organic materials escaping carbon are believed to be largely colloidal.

Both laboratory and field studies of carbon adsorption have been conducted. A 200 gpm pilot plant using granular carbon and employing thermal reactivation will be activated in Pomona, California in late 1964.

B Principal factors in the use of activated carbon for treating municipal effluents have been:

1 Contact times of 15-30 minutes in granular beds or 3-5 minutes with powdered carbon are required.

2 Carbon reactivation is necessary to reduce costs to acceptable levels. Thermal regeneration has been proven practical. The actual technology for reactivating granular carbon on a large scale is known. While reactivation of powdered carbon has been shown feasible, the technology is in an early stage.

3 Pretreatment of an effluent ahead of the activated carbon may be required.

4 0.5 to 1 lb of carbon will treat 1,000 gal of secondary effluent.

5 Preliminary cost projections for reduction of 50-70 ppm of organic material (COD) to 10-15 ppm are from 5-10c/1,000 gallons of wastewater for plants larger than 10 mgd. This includes both amortization and operating cost but no pretreatment.

6 Inorganic salts are not removed by carbon.

III FOAM SEPARATION

A Most municipal effluents treated by a secondary process foam easily when agitated. Somewhat surprisingly, primary effluents foam less than secondary effluents. The true cause of the foaming is complex although the presence of ABS is a contributing major factor. The foaming tendency of secondary effluents is expected to be greatly reduced when biodegradable detergents come into full use. When air is deliberately blown through an effluent at an appropriate rate, particularly in a column, foam is formed and can be collected and condensed into a small volume which will contain 85-95 percent of the ABS and perhaps 25-35 percent of the total organic residues remaining in the effluent. Foam separation is aimed primarily at removal of dissolved surface active contaminants; while flotation effects occur, the primary purpose of the treatment is not flotation of suspended solids. Inorganics, which are nonsurface active in nature, are not removed by the process.

B Following a series of laboratory studies on foaming, a 0.5 mgd pilot plant has been constructed in Pomona, California and a testing program is underway. Engineering correlations are being obtained relating product quality and collapsed foam volume to gas-to-liquid ratio, liquid residence, time, liquid height, and foam height. Optimum conditions will be approximately:

Gas-to-liquid ratio--5:1

Liquid residence time--5 minutes
Liquid depth--5 to 6 ft

Foam height above liquid--1.5 to 2 ft
Collapsed foam volume to feed volume--1:100

C It has been found that foams may be readily collapsed by sprays of the collapsed foam itself. Disposal of the collapsed foam has not yet received extensive study. Laboratory studies by the California Research Corporation indicate that recycle of the condensed foam to the activated sludge process achieves degradation of ABS and COD materials, and serves as an effective foam disposal method.

D Even if biodegradable detergents lessen or eliminate foaming tendencies of treated effluents, it is not inconceivable that foam producing compounds to enhance removal of organics may be added. Some preliminary tests indicate that certain polyelectrolytes may enhance the foam separation process, especially for primary effluents. Studies are continuing along these lines. Foaming will probably be used principally to produce a nonfoaming effluent or to prepare a liquid of reduced organic content which may then be fed to other processes. The projected cost of less than 2c/1,000 gallons, the short residence time for treatment, and the simplicity of the process make it attractive as a possible treatment method.

PILOT UNIT FOR FOAM SEPARATION, POMONA, CALIFORNIA

Secondary effluent is fed to the foamer. Diffused air is blown through the effluent to form foam. The foam is condensed by spraying with condensed foam and is removed taking organic contaminants with it.

IV ELECTRODIALYSIS

A As more and more water reuse occurs, inorganic buildup is inevitable. The Public Health Service Drinking Water Standards recommend that 500 mg/l of total dissolved solids not be exceeded and more specifically that sulfates should not exceed 250 mg/l, nitrates (NO_3^-) not more than 45 mg/l, and chlorides not more than 250 mg/l. Fluoride should be present at an optimum level of about 1 mg/l. Because of the addition of inorganic salts to water during use, it is clear that inorganic materials will have to be controlled in water reuse situations to meet the above standards. The amount of inorganic removal needed would be expected to average 300-400 mg/l.

B Electrodialysis has the capability of reducing the concentrations of inorganic ions in water and is already a commercially proven process. The brackish water source of Buckeye, Arizona, for example, is converted to a usable supply by electrodialysis. Various other commercial applications of electrodialysis also exist.

C Contract research studies have shown that inorganic ionic materials in waste effluents can be reduced by electrodialysis on a relatively nonselective basis. Feed to the electrodialysis process should be nearly free from organic contaminants, however. While removal of some organics would occur during electrodialysis, the membranes are eventually fouled by them and a rather difficult regeneration is required. Suspended solids must also be at a very low level to avoid physical plugging of the electrodialysis cells. A pilot plant electrodialysis installation with a capacity of 50 gpm and operating on an actual municipal effluent is to be installed in the Cincinnati area in late 1964.

D Some of the significant findings on electrodialysis of municipal wastewaters have been:

1 6-10 kwh/1,000 gallons is the estimated power requirements to remove 300-500 mg/l of solids.

2 Product to waste volumes of 10:1 can readily be achieved and 50:1 has been accomplished.

3 Total cost for electrodialysis will vary with the amount of materials removed. Very preliminary estimates indicate that 15-20c/1,000 gallons may be the range for municipal effluents. It should be emphasized that this cost does not include allowance for necessary pretreatment or for ultimate disposal of the brine concentrate.

ELECTRODIALYSIS INSTALLATION AT BUCKEYE, ARIZONA

This process is used to demineralize brackish ground water for municipal use. Experimental studies indicate that wastewaters can be demineralized by this technique.

V EVAPORATION

A Nature's water cycle relies on evaporation and condensation. The term "distilled water" connotes purity and from a technical standpoint, evaporative processes have attractive possibilities. Simple distillation of wastewater effluents, however does not ordinarily produce a drinkable product. Volatile contaminants such as ammonia and low boiling organics appear in the distillate. However, pretreating, venting, or activated carbon polishing of the product can prevent or control problems caused by volatiles. Below 5-10 ppm inorganics and less than 2-3 ppm of organic carbon appear in the distillate from a secondary effluent feed.

B The existing technology of distillation will be drawn on heavily in studies of distillation of wastewaters, but key questions relating to wastewaters have to be answered experimentally. Besides product quality problems of volatile materials, the effects of organics on scale and corrosion are unknown. The presence of phosphates may even have a beneficial effect in preventing scale. The relative merits of high temperature versus low temperature distillation will have to be assessed. The approach of the Advanced Waste Treatment Research Program to evaporation has been to support desk-top analyses by distillation experts followed by small scale experimental studies. At present a small pilot study (1,000 gpd) of a multi-stage flash still and using real effluents as feed is just getting underway.

C It is currently impossible to assess accurately the cost of distillation. Costs are not expected to exceed costs of distilling sea water and wastewater distillation may even be cheaper for the following reasons:

1 Lower boiling point elevation

2 Lower volume feed to be handled per unit of product water

3 Lower volume of brine to be disposed of per unit of product water

4 Higher top temperatures possible.

D A significant factor in considering distillation, or any "complete removal" process, is that blending of the highly pure product with other water would not only be desirable but would greatly reduce the unit cost of the water produced. With blending concepts and the possibility of making use of waste heat sources or of combining power production and water renovation systems, the potential application of distillation to wastewaters deserves considerably study.

VI LIQUID-LIQUID EXTRACTION

A Certain solvents such as five and six carbon secondary and tertiary amines are partially miscible with water to an extent depending mainly on the temperature and salt content of the water. The associated water-solvent mixture is separated from the brine; next, the solvent is separated from the clean water by a change of temperature. The solvent is recycled while the product water is air stripped or otherwise treated to recover residual solvent. Such systems have received extensive study in the desalination field for removal of inorganic salts. The technique has recently been applied to municipal waste effluents under AWTRP sponsorship. A product of 5-7 ppm organics has been obtained and the total dissolved solids have been reduced from 500 to less than 150 ppm. Some organic materials, notably, ABS transfer to the solvent phase and must be removed during a solvent regeneration step. Precoagulation of the feed is advantageous. Calcium is removed to a higher degree than sodium and, strangely, the process appears not to remove nitrate ions.

B Solvent remaining in the water after phase separation is air stripped to a concentration of about 5 ppm. Although such a residual concentration is not noticeable by taste or odor, it would probably be removed by activated carbon polishing.

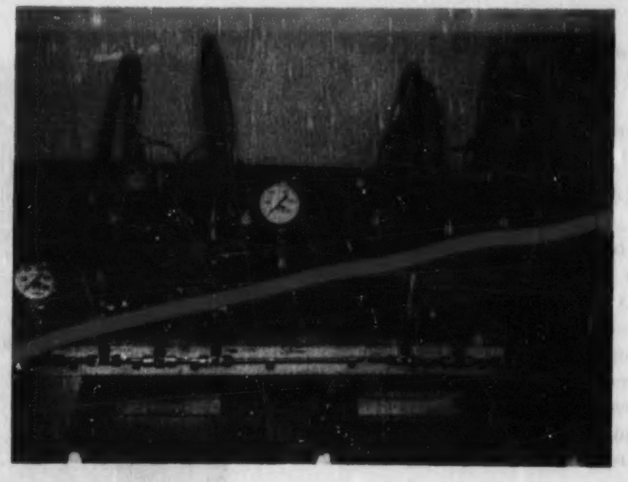
EXTRACTION APPARATUS FOR SEPARATING WASTEWATER AND CONTAMINANTS

Amine solvents are brought into intimate contact with wastewater. The solvent-water layer is separated from the brine and the solvent and clean water are separated. Solvent is recycled.

C Accurate costs of the process are not known and will depend among other things on the amount of materials removed. Best projections indicate that water can be produced for not over 50c/1,000 gal. and probably for somewhat less. While the extraction process appears worthy of further study, fund limitations have caused a temporary discontinuance of research.

VII REVERSE OSMOSIS

A Quite pure water can be separated from municipal effluents by forcing water through a semi-permeable membrane composed of cellulose acetate containing inorganic additives. Pressures of 750 psi are required. Organics, inorganics and



REVERSE OSMOSIS TEST CELL

When wastewater is forced through a special membrane, contaminants are left behind. Good quality water has been produced on laboratory scale tests.

even bacteria and viruses are "filtered" out by the membrane. The exact mechanism of the separation is not known. Product water of 50 ppm total dissolved solids and less than 5 ppm organic materials can be produced. In short-time trials, flux rates of 15-20 gpd/ft^2 could be attained. Life of membranes stability of flux rates, and optimum process conditions are yet to be determined.

B This process is interesting because of its theoretical energy advantages over phase change processes. Further studies are felt desirable but, as with extraction, efforts have ceased temporarily.

VIII FREEZING

A Under proper conditions of freezing the ice crystals formed even from impure water are quite pure. Freezing processes have received extensive study for converting saline water to fresh water. Contaminants adhere to the ice crystals and the success of the process depends on the effective washing of these crystals. Under proper washing conditions a high quality product water can be obtained.

B The feasibility of freezing waste effluents has been investigated and a suitable product can be obtained. Large agglomerates of ice are formed, however, compared to the fine slush formed when sea water is frozen. Although of interest to the Advanced Waste Treatment Research Program, freezing processes are not high enough in priority to permit further funding at present.

IX SOLIDS REMOVAL

A Most effluents from conventional processes contain suspended and colloidal solids which are nearly all organic materials. Effective removal of these materials is a way of improving the quality of an effluent. Solids removal is also necessary to prepare effluents for further advanced treatments. In addition, for recreational water, removal of algae becomes important. While techniques for removing suspended solids are among the oldest in use, little has been done directly on municipal effluents. One approach is to treat the effluent with alum and lime. Under proper conditions, a poorer than normal quality activated sludge effluent could be so

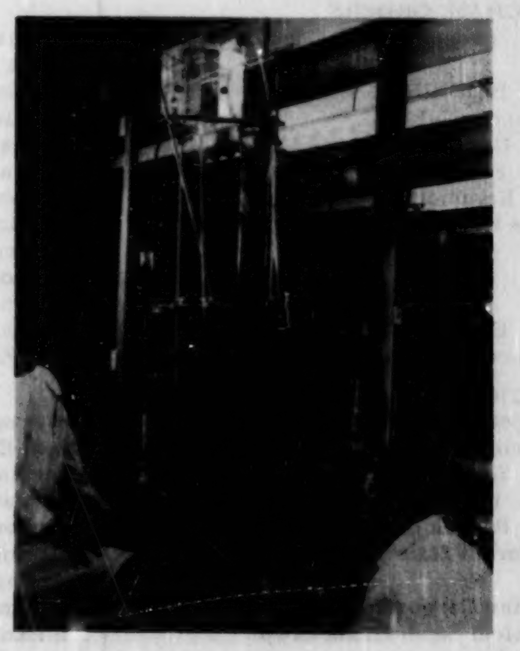
FREEZING PROCESS

Experimental freezing tests have been made on secondary effluents. A good product can be prepared. Agglomeration of large masses of ice and washing are problems.

treated and a high quality effluent low in suspended solids would result. An added benefit of such chemical treatment at the end of a conventional process is phosphate removal. Various combinations of filter media, addition of polyelectrolytes, diatomaceous earth filtration, flotation and other solids removal methods are under study. All such studies are in an early stage.

X OXIDATION

A Removal of organic contaminants by chemically oxidizing them to carbon dioxide and water would be highly attractive as a treatment method. Even altering organic structures so that foam is not produced or making the materials amenable to other treatment are possible uses of oxidation. Air or molecular oxygen do not serve well as oxidants for organic residues in effluents. However, active oxygen in the form of free hydroxyl radicals (·OH) is a strong oxidant in aqueous systems and will oxidize organic compounds containing hydrogen and will attack many other ions such as the halogens. Needed is an economical way to produce the (·OH) radical. Since chain oxidation reactions may occur it would be beneficial to initiate such a reaction which could then be continued by supplying air or molecular oxygen which are inexpensive.



SOLIDS REMOVAL BY FILTRATION

Various combinations of coarse and fine media are tested for removal of suspended solids from effluents.

B Using iron salts and hydrogen peroxide, the (·OH) radicals can be generated and this system has been applied under laboratory conditions to actual effluents. Refractory organic materials (COD 15 to 35 ppm) were reduced by this treatment by 50 to 70 percent. A pH of 3 to 4 was required and when ferrous salts were used, ambient temperatures were adequate, ABS was removed with 98 percent efficiency. In some tests oxidation efficiency, defined as the change in COD (mg/l) divided by the available O_2 (mg/l) × 100, exceeded 100 percent indicating that some oxidation by molecular oxygen took place. From 30 to 65 percent of the organic carbon was actually oxidized to CO_2.

C Supplying free radicals from hydrogen peroxide is too expensive for consideration. Other oxidation systems are now under study and contract research to study the generation of (· OH) radicals by a corona discharge has just been undertaken. Oxidation may find most use as a polishing treatment following other processes.

XI SUMMARY OF AWTR CONTRACTS TO JUNE 30, 1964

Name	Area of work
PURCHASE ORDERS:	
W.L. Badger Assoc., Inc.	Discussion of various processes for removal of soluble materials from wastewater
A.J. BARDUHN	Freezing and Hydration Distillation
Clemson College	Literature Search
J.A. Gerster	Distillation
K.C. Hickman	Distillation and Other Processes
Karl Kammermeyer	German Literature Search
Louis Koenig Research	Technical Spec. for AWT Processes, Series of Reports
" " "	Incineration
" " "	Injection to Underground Formations
" " "	Placement in Underground Cavities and Spreading
D.F. Othmer	Distillation and Evaporation
Richard D. Pomeroy	AWT Parameters
CONTRACTS	
Aerojet-General	Reverse Osmosis
American Machine and Foundry	Flash Evaporation
App. Science Labs., Inc.	Freezing
W.L. Badger Assoc., Inc	Distillation
U,S. Bureau of Mines	Adsorption on coals
California State Dept. of Health	Determine consumer attitudes toward mineralized water supplies
Carrier Corporation	Freezing
Chemical Separations Corp.	Ion Exchange Regenerant Recovery
Dorr-Oliver, Inc.	Feasibility of Powdered Activated Carbon
Dow Chemical	Evaluation of Carbon Analyzer
Dow Industrial Service	Evaluations of use of activated carbons and chemical regeneration in treatment of sec. sewage plant effluents
Esso Research and Eng. Co.	Foaming and Foaming-Adsorption
General Electric Co.	Corona Discharge
President and Fellows of Harvard College	Adsorption
Infilco, Inc.	Coagulation-Filtration
Ionac Chemical Corp.	Coagulation, adsorption and sludge blanket filtration
Ionics, Inc.	Electrodialysis and Ion Exchange
Ionics, Inc.	Design and Construct Electrodialysis Pilot Plant
Louis Koenig Research	Oxydation
" " "	Ultimate Disposal
" " "	Market Projection

SUMMARY OF AWTR CONTRACTS TO JUNE 30, 1964 (Cont'd)

Name	Area of work
Los Angeles Co. San. Dists.	Recreational Reuse, Foaming and Cost Quality
D. F. Othmer	Extraction
Pennsalt Chemical Company	Electrochemical Degradation
Pittsburgh Chemical Co.	Adsorption
" " "	Adsorption
Polytechnic Inst. of Brooklyn	Electrodialysis and Ion Exchange
Radiation Applications, Inc.	Foaming
Syracuse University Res. Inc.	Eutectic Freezing
Texas A & M	Solvent Extraction
University of California	Foam Separation

This outline was prepared for the Training Program by F. M. Middleton, Chief, Advanced Waste Treatment Research Program, Division of Water Supply and Pollution Control SEC. Reprinted from Water and Sewage Works Journal, September 1964, with permission from the editors.

Outline Number

MAN - WATER - AIR

Man - An Ecological Factor in the Environment

Air and Water - Dependent or Independent?

ESTUARY PROBLEMS IN WATER QUALITY MANAGEMENT

	Outline Number
Introduction - Marine Waters, Known and Unknown	42
Physical and Chemical Aspects of the Marine Environment	42
General Concepts of Estuarian Problems	43
Specific Application of Analyses to the Estuarine Environment	44
Administrative Considerations in Estuarine Analysis	45

INTRODUCTION - MARINE WATERS, KNOWN AND UNKNOWN

I INTRODUCTORY REMARKS

A Some chemical characteristics of sea water.

B Estuaries - where the sea meets the land.

II TYPES OF ESTUARIES

A Basin characteristics

- 1 Fjord - type
  - a Shallow sill
  - b Deep sill
- 2 Drowned river valleys
- 3 Offshore bar

B Circulation characteristics

- 1 Unstratified
- 2 Slightly stratified
- 3 Strongly stratified
- 4 Salt wedge
- 5 Miscellaneous

III IMPORTANCE OF ESTUARIES TO ECOLOGY OF THE SEA

A Endemic populations important to man

B Breeding grounds for many marine species

C Pollution problems

IV DISTRIBUTION OF ORGANISMS IN ESTUARIES

A The brackish water species

B Estuarine zones of transition and conflict

C Salinity tolerances of organisms

D Distribution of selected species

V VARIATIONS IN ESTUARINE CONDITIONS

A Salinity fluctuations

- 1 Along estuary
- 2 Cyclic tidal variations
- 3 Seasonal variations - relationship to river flow
- 4 Transient variations - wind effects

This outline was prepared for the Training Program by Bostwick H. Ketchum, Associate Director for Biology and Chemistry, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

PHYSICAL AND CHEMICAL ASPECTS OF THE MARINE ENVIRONMENT

I INTRODUCTION

A Water is a particularly fit environment for living things.

B Water is found in cavities of rocks and minerals, as ground water, spring water, in lakes and rivers and estuaries, and most importantly as sea water.

C The total volume of the ocean has been estimated to be about $13,722 \times 10^{20}$ ml.

D Sea water is remarkably constant in composition in all parts of the earth and probably contains all elements in solution.

II WATER

A Water is a highly organized liquid in which the molecules are arranged in a clear cut configuration.

B Pure water has a number of physical characteristics which are unique and are biologically critical. These characteristics depend in large part on the molecular structure of water.

III THE OCEAN AS ENVIRONMENT

A The ocean is an almost ideal environment for all living things because of the relative lack of variability in chemical and physical characteristics. Temperature, oxygen content, carbon dioxide concentrations, salt concentrations all remain relatively constant and hence protect living organisms from unfavorable environmental insults.

IV SOME PHYSICAL ASPECTS OF THE MARINE ENVIRONMENT

A In the open ocean sea water is quite clear, ordinarily is bright blue in color, and is transparent; these characteristics are modified in estuaries.

B The high specific heat of water protects individual organisms from damaging temperature changes in the marine environment.

C Pressure increases regularly with greater depth in the ocean. However, the tremendous pressures which develop in the depths of the ocean have no harmful effects on living tissues because the latter are permeated by a fluid medium in intimate contact with the surrounding water.

D The intensity of light decreases as the depth in the ocean increases. The rate of decrease in intensity of illumination varies depending on the wave length of light in question.

V SOME CHEMICAL CONSIDERATIONS

A The chlorinity and salinity of water are used extensively in studies on the marine environment. They are related to one another as follows:

Salinity (^{o}/oo) = 0.0313 + 1.80488 Chlorinity (^{o}/oo)*

B Ordinarily, oxygen is not a major limiting factor for life and growth in the ocean.

C The amount of carbon dioxide in sea water varies from 34 to 56 ml per liter. An equilibrium exists in the system involving dissolved carbon dioxide, bicarbonate, and carbonate.

D In the open ocean salinity varies between 33 ^{o}/oo and 37 ^{o}/oo with a mean of about 35 ^{o}/oo.

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* ^{o}/oo = per thousand

E Phosphorus which is one of the most biologically important elements in the ocean occurs in amounts which vary from 0.001 to 0.17 mg per kg of sea water.

VI In any evaluation of biologically active chemical compounds in the ocean it is important to keep in mind two phenomena which are very real and are critical: synergism and antagonism.

VII ESTUARIES

A Estuaries are bodies of water in which river water mixes with sea water and dilutes the latter measurably. River water differs from sea water with respect to dissolved materials.

B It is important to remember that the estuary is an unique environment which poses peculiar problems in biology, chemistry, and physics.

C The Patuxent River is a fairly good example of an estuary. Studies made at Solomons, Maryland by the staff of the Chesapeake Biological Laboratory illustrate the variability of the chemical and physical characteristics of estuarine environment.

VIII FOREIGN OR POLLUTING SUBSTANCES

A Because each estuary presents an unique problem depending on its size, shape, flushing rate, and similar considerations it is very difficult to generalize on pollution problems in such bodies of water.

B The list of materials potentially hazardous to marine organisms is very long and runs from abietic acid to zinc.

C Radioactive materials pose a separate problem which requires particular attention.

D Adaptation to some pollutants is theoretically possible but the degree and mechanism of such adaptation are not well known.

IX SOME RESEARCH SUGGESTIONS

A There are innumerable unsolved problems which face biologists, chemists, and physicists as well as engineers with respect to the marine environment.

B The causes behind and the mechanisms involved in the distribution of planktonic organisms are completely unknown.

C The interrelation of various chemical and physical factors in determining the distribution of communities and other associations of animals and plants needs study.

D The interrelations between atmosphere and ocean are, at best, poorly understood but are basic to a clear understanding of the dynamics of the marine environment.

E Classical hydrodynamics has been found wanting with respect to a method of evaluation of coastwise and estuarine circulation. Simple diffusion problems alone need intensive and extensive study.

F The energy balance in estuaries and coastal waters, including the food chain cycle of a complete area such as Narragansett Bay, needs serious and intensive study.

Table 1. A SUMMARY OF SOURCES OF PRESENT KNOWLEDGE OF THE PHYSICAL PROPERTIES OF SEA WATER

Density of Sea Water at Atmospheric Pressure	C. Despretz	1937	Showed that water does not have density maximum above freezing point.
	M. Knudsen	1901	Prepared tables of sea water density at atmospheric pressure based on his measurements.
	T.G. Thompson H.E. Wirth	1931	Checked Knudsen's determination of density at 0°C and found it satisfactory.
Compressibility	Canton	1762	First to show water is compressible.
	P.G. Tait	1889	First extensive series of compressibility measurements.
	V.W. Ekman	1908	Measurements used in present tables.
Specific Heat	J. Thoulet A. Chevallier	1889	C_p measured at 17.5°C.
	R.A. Cox	1958	Complete determination of C_p at atmospheric pressure.
Freezing Point	M. Knudsen	1903	Measured temperature of equilibrium of pure ice with sea water.
	Y. Miyake	1939	
Vapor Pressure	R. Witting	1908	Calculated from freezing-point depression.
	K. Higashi K. Nakamura R. Hara	1931	Vapor pressure of sea water at high temperatures 25°C to 175°C.
	A.B. Arons C.F. Kientzler	1954	Vapor pressure in range - 10°C to 35°C.
Viscosity	O. Krummel	1907	Decreases rapidly with temperature and increases slightly with salinity.
Thermal Conductivity	O. Krummel	1907	Computed from assumption (k/pc_p) sea water = (k/pc_p) pure water.

Table 1. (Cont'd) A SUMMARY OF SOURCES OF PRESENT KNOWLEDGE OF THE PHYSICAL PROPERTIES OF SEA WATER

Electrical Conductivity	E. Ruppin	1906	Specific conductance increases with temperature and salinity.
	B. D. Thomas T.G. Thompson C.L. Utterback	1934	
	W. Bein H.G. Hirsekorn L. Moller	1935	
Surface Tension	O. Krummel	1907	Higher than pure water at same temperature.
Refractive Index	O. Krummel	1907	Increases with,temperature and salinity..
	C.L. Utterback T.G. Thompson B.D. Thomas	1934	
	W. Bein H.G. Hirsekorn L. Moller	1935	
	Y. Miyake	1939	

Table 2. THE MAJOR CONSTITUENTS OF SEA WATER

Chlorinity = 19.00 °/oo*

Ion	Parts per Million	Equivalents per Million	Parts per Million per Unit Chlorinity
Chloride, Cl^-	18,980.0	535.3	998,90
Sulfate, SO_4^{--}	3,649.0	55.1	139.40
Bicarbonate, HCO_3^-	139.7	2.3	7.35
Bromine, Br^-	64.6	0.8	3.40
Fluoride, F^-	1.3	0.1	0,07
Boric acid, H_3BO_3	26.0	....**	1.37
Total		593.6	
Sodium, Na^+	10,556.1	459.0	555.60
Magnesium, Mg^{++}	1,272.0	104.6	66.95
Calcium, Ca^{++}	400.1	20.0	21.06
Potassium, K^+	380.0	9.7	20.00
Strontium, Sr^{++}	13.3	0.3	0.70
Total		593.6	

*°/oo is used to denote grams per kilogram or parts per thousand.

** Undissociated at usual pH.

Table 3. ELEMENTS PRESENT IN SOLUTION IN OCEANIC SEA WATER EXCLUSIVE OF DISSOLVED GASES

Chlorinity = 19.00 ‰

Element	Parts per Million	Element	Parts per Million
Chlorine	18980	Copper	0.001-0.01
Sodium	10561	Zinc	0.005
Magnesium	1272	Lead	0.004
Sulfur	884	Selenium	0.004
Calcium	400	Cesium	0.002
Potassium	380	Uranium	0.0015
Bromine	65	Molybdenum	0.0005
Carbon	28	Thorium	0.0005
Strontium	13	Cerium	0.0004
Boron	4.6	Silver	0.0003
Silicon	0.02-4.0	Vanadium	0.0003
Fluorine	1.4	Lanthanum	0.0003
Nitrogen*	0.006-0.7	Yttrium	0.0003
Aluminum	0.5	Nickel	0.0001
Rubidium	0.2	Scandium	0.00004
Lithium	0.1	Mercury	0.00003
Phosphorus	0.001-0.10	Gold	0.000006
Barium	0.05	Radium	$0.2\text{-}3\times10^{-10}$
Iodine	0.05	Cadmium	present
Arsenic	0.002-0.02	Cobalt	present
Manganese	0.001-0.01	Tin	present

*Nitrogen in combined forms.

Table 4 CHLORINITY, SALINITY, AND SPECIFIC GRAVITY OF SEA WATER

Chlorinity ‰	Salinity ‰	Specific Gravity at 17.5°C	Chlorinity ‰	Salinity ‰	Specific Gravity at 17.5°C
0.00	0.00	1.00 000			
1.00	1.84	0 144	12.00	21.69	1.01 658
2.00	3.64	0 283	13.00	23.50	1 795
3.00	5.45	0 421	14.00	25.30	1 933
4.00	7.25	0 558	15.00	27.11	1.02 070
5.00	9.06	1.00 696	16.00	28.91	2 208
6.00	10.86	0 834	17.00	30.72	2 346
7.00	12.67	0 971	18.00	32.52	2 484
8.00	14.47	1 109	19.00	34.33	2 622
9.00	16.28	1 246	20.00	36.13	1.02 760
10.00	18.08	1.01 383	21.00	37.94	2 899
11.00	19.89	1 521	22.00	39.74	3 037

Table 5. DENSITY OF SEA WATER AS A FUNCTION OF TEMPERATURE AND SALINITY

Salinity Parts per Thousand	Temperature, °C							
	0	5	10	15	17.5	20	25	30
0	0.99987	1.00000	0.99973	0.99913	0.99870	0.99813	0.99707	0.99567
5	1.00397	0401	1.00367	1.00301	1.00257	1.00207	1.00086	9943
10	0801	0796	0756	0684	0638	0585	0461	1.00314
15	1204	1191	1144	1067	1019	0964	0836	0686
20	1.01606	1.01585	1.01532	1.01449	1.01399	1.01341	1.01210	1.01057
25	2008	1980	1920	1832	1779	1720	1585	1429
30	2410	2374	2308	2215	2160	2099	1960	1801
35	2813	2770	2698	2600	2542	2479	2337	2176
40	1.03216	1.03166	1.03088	1.02985	1.02925	1.02860	1.02715	1.02551

Table 6. PROPERTIES OF SEA WATER OF DIFFERENT SALINITY

Salinity, °/oo	Freezing Point, °C	Temperature of Maximum Density, °C	Osmotic Pressure Atmospheres	Specific Heat
0	0.00	3.95	0	1.00
5	-0.27	2.93	3.23	0.982
10	-0.53	1.86	6.44	0.968
15	-0.80	0.77	9.69	0.958
20	-1.07	-0.31	12.98	0.951
25	-1.35	-1.40	16.32	0.945
30	-1.63	-2.47	19.67	0.939
35	-1.91	-3.52	23.12	0.932
40	-2.20	-4.54	26.59	0.926

Table 7. SATURATION COEFFICIENT VALUES OF OXYGEN AND CARBON DIOXIDE IN WATER

Salinity (%)	Temperature (°C)					
	0°		12°		24°	
	O_2	CO_2	O_2	CO_2	O_2	CO_2
0 (fresh water)	49.24	1717	36.75	1118	29.38	782
28.9	40.1	1489	30.6	980	24.8	695
36.1 (sea water)	38.0	1438	29.1	947	23.6	677

Concentrations are expressed as ml/l at sea level atmospheric pressure.

Table 8. ATMOSPHERIC GASES IN OCEAN WATER

	Milliliters per Liter	Parts per Million
Oxygen	0-9	0-12
Nitrogen	8-15	10-18
Carbon dioxide*	33-56	64-107
Argon	0.2-0.4	0.4-0.7
Helium and neon	1.7×10^{-4}	0.3×10^{-4} **

* Includes CO_2 present as H_2CO_3, HCO_3^-, and CO_3^{--}.

** Estimated as helium.

Table 9. OXYGEN DISSOLVED IN SEA WATER IN EQUILIBRIUM WITH NORMAL ATMOSPHERE (760 mm) OF AIR SATURATED WITH WATER VAPOR

Parts per Million					
Chlorinity °/oo Salinity °/oo	0 0	5 9.06	10 18.08	15 27.11	20 36.11
Temperature °C					
0	14.62*	13.70	12.78	11.89	11.00
5	12.79	12.02	11.24	10.49	9.74
10	11.32	10.66	10.01	9.37	8.72
15	10.16	9.67	9.02	8.46	7.92
20	9.19	8.70	8.21	7.77	7.23
25	8.39	7.93	7.48	7.04	6.57
30	7.67	7.25	6.80	6.41	5.37

* The values for solubility in water of zero chlorinity differ slightly from those given for fresh water.

Table 10. PERCENTAGE COMPOSITION OF DISSOLVED SOLIDS IN SEA WATER AND RIVER WATER

Substance	Sea Water	River Water Weighted Average	Mississippi River	Columbia River	Colorado River
CO_3^{--}	0.41(HCO_3^-)	35.15	34.98	36.15	13.02
SO_4^{--}	7.68	12.14	15.37	13.52	28.61
Cl^-	55.04	5.68	6.21	2.82	19.92
NO_3^-	....	0.90	1.60	0.49	.....
Ca^{++}	1.15	20.39	20.50	17.87	10.35
Mg^{++}	3.69	3.41	5.38	4.38	3.14
Na^{++}	30.62	5.79	8.33	8.12	19.75
K^+	1.10	2.12	.....	1.95	2.17
$(Fe, Al)_2O_3$	....	2.72	0.58	0.08	.....
SiO_2	....	11.67	7.05	14.62	3.04
Sr^{++}, H_3BO_3, Br^-	0.31	.....	.....	.....	.....
Salt content, ppm	35,000	.....	166	92.4	702

Table 11. PENETRATION OF DAYLIGHT INTO OCEAN WATER

Depth m.	Wavelength, mμ							
	380		435		570		650	
	O	C	O	C	O	C	O	C
10	50	20	80	25	50	25	3	0.5
50	20	0.2	50	0.4	5	0.45	0.1	0.0

Values are in percentage of surface light.
O refers to open ocean; C to continental waters.

Table 12. TABLE SHOWING THE VARIATION IN SALINITY IN CHESAPEAKE BAY, A SITUATION NOT OBTAINING IN THE OPEN OCEAN

Location of Station	Depth (m.)	Surface Salinity (°/oo)	Bottom Salinity (°/oo)	Surface-bottom Difference (°/oo)	Surface-bottom Difference (%)
Howell Point	10	.50	.77	.27	54
Hart Island	5	2.82	3.05	.23	8
Matapeake	30	7.12	18.44	11.32	160
Sharp's Island	20	8.71	19.92	11.21	129
Cove Point	35	10.74	21.75	11.01	103
Point No Point	28	12.13	22.55	10.42	86
Great Wicomico	30	13.55	23.59	10.04	74
Wolf Trap Light	15	17.17	24.38	7.21	42
Cape Charles	10	23.50	31.06	7.56	32

REFERENCES

1 Conference on Physical and Chemical Properties of Sea Water. Easton, Md. 1958. Washington. National Academy of Sciences. National Research Council. 202 pp. NRC Publ. No. 600. 1959.

2 Fox, C.S. Water. The Philosophical Library. New York. 148 pp. 1952.

3 Garland, C.F. A Study of Water Quality in Baltimore Harbor. Chesapeake Biological Laboratory. Publ. No. 96. Solomons Island, Md. 132 pp. 1952.

4 Nash, C.B. Environmental Characteristics of a River Estuary. Sears Found. J. Mar. Res. 6:147-174. Chesapeake Biological Laboratory. Solomons Island, Md. Publ. No. 64. 1947.

5 Redfield, A.C. Characteristics of Sea Water. The Corrosion Handbook. J. Wiley. New York. p.1111-1122. 1948.

6 Reid, G.K. Ecology of Inland Waters and Estuaries. Reinhold. New York. 375 pp. 1961.

7 Sillen, L.G. The Physical Chemistry of Sea Water. Oceanography. Publ. No. 67. p. 549-581. A.A.A.S. Washington. Edited by Mary Sears. 1961.

8 Sverdrup, A.U., Johnson, M.W., and Flemming, R.H. The Oceans. Prentice-Hall. New York. 1087 pp. 1942.

This outline was prepared for the Training Program by Dr. Charles G. Wilber, Professor of Biological Sciences, Kent State University, Kent, Ohio.

GENERAL CONCEPTS OF ESTUARIAN PROBLEMS

I NATURE OF THE PROBLEM

A general discussion of the pollution of natural waters, oceans, lakes, estuaries and streams. The general equation of mass balance which may be applied to all of these bodies. Application of the general equation to estuarine systems. Comparison between estuaries and freshwater streams.

II PHYSICAL DESCRIPTION OF THE PROBLEM

A description of the various factors which affect the concentration profiles of contaminants in estuaries: dispersion, advection and reaction. The influence of the tidal phenomenon on the concentration profiles including the saline intrusion and density differences. The geomorphology of various estuaries and the general forms of their physical structures. The effect of freshwater flow and temperature on water quality in the estuaries. The temporal variation of these parameters: daily, monthly and seasonally. The various types of wastewater inputs ... point and distributed sources. A discussion of the various boundary conditions, e. g. the efflux of the estuary into the ocean, the dilution of a tributary stream, the effects of a dam. The various factors which affect both conservative and non-conservative substances from the physical, chemical and biological viewpoints.

III MATHEMATICAL DESCRIPTION AND EQUATIONS

Incorporation of the above into the fundamental differential equation which describes the temporal and spatial distribution of contaminants in estuaries. The nature and variation of the coefficients of dispersion, advection and reaction from a mathematical point of view. The continuous versus the segmented methods of analysis. The application of linear system analysis to estuaries and of superposition to multiple loadings. The application of the geomorphological characteristics of estuaries to determine the geometric coordinate systems. The various functions which mathematically describe this phenomenon and in particular the Bessel functions. The importance and application of the instantaneous release of mass. The use of physical, hydraulic and mathematical model. The application of the analog and digital computers to estuarine analysis.

IV WASTEWATER INPUTS - SOURCES AND SINKS

The temporal and spatial variation of various wastewater inputs. The significance of these variations; the nature of the pollutants as affecting estuarine water quality. Intermittent versus continuous discharge of wastewaters: storm overflow and batch discharges versus release from continuous sources. The various reactions of a physical, chemical and biological nature which affect water quality characteristics in estuaries. Application to concentration of solids and BOD and distribution of bacteria and algae. A discussion of the numerous elements which influence the dissolved oxygen concentration. A consideration of both the carbonaceous and nitrogeneous cycles in the oxidation of organic matter. The effect of waste treatment on water quality and the significance of the nitrification stage.

V APPLICATION OF THE ANALYSIS TO ASSIMILATION CAPACITY - PLANNING AND MANAGEMENT

The physical and mathematical analysis as described above, is applied to various examples of estuarine pollution and analysis. Discussion of survey procedures and techniques and the analysis of survey data. Determination and correlation of the significant coefficients and their application to wastewater treatment requirements.

Drainage basin planning for present and future needs. Examples from New York Harbor, East and Hudson River, Delaware Estuary, lower James River and Sacramento River.

This outline was prepared for the Training Program by Professor Donald J. O'Connor, Professor of Civil Engineering, Manhattan College, Bronx, New York.

SPECIFIC APPLICATION OF ANALYSES TO THE ESTUARINE ENVIRONMENT

I THE ANALYTICAL FRAMEWORK

A Evaluation of Available Data in Light of Formulation of Mathematical Model

1 May require some preliminary analyses

a Mean spatial water quality profiles

B Formulation of Estuary in a Mathematical Model

1 Recognition of important phenomena

a Diffusion, net flow

2 Examples of models

a Streeter-Phelps DO model

b Bacterial die-off model

c Diffusion and flow transport model

C Formulation of Water Quality Management Models

1 Specification of water quality goals

2 Examples of models

a Least regional cost model

b Uniform per cent removal model

c "Zoned" per cent removal model

D Detailing of "Data Gaps" That Must Be Filled for Operation of Model

1 Usual gaps in estuary work

a Current speed and direction

b Magnitude of diffusion mechanism

c Meteorological variables

2 Cost of treatment data usually missing in all work.

II APPLICATION AND USE OF ANALYTICAL FRAMEWORK OF THE DELAWARE ESTUARY

A Basic Concepts of Water Quality Forecasting Model of Delaware Estuary

1 Dissolved oxygen (DO) as indicator

2 The estuary as a "system"

a Figure 1 - for examples of "systems"

3 Differences between inputs, outputs and system components.

4 The segmentation of the estuary

B Some Typical Results of DO Model of Delaware Estuary

1 Cataloguing of average (steady-state) input-output relationships

a Table 1 - example of waste load input - DO output relationships for Delaware Estuary.

2 Transient input-output relationships

a Table 2 - "spike" waste load input - DO time response.

C Some Results of Optimum (Least Cost) DO Improvement Model of Delaware Estuary.

1 Need input-output information of Table 1.

2 Need cost of waste treatment data.

3 Examples of solution - Table 3 - some results from least cost solutions for the Delaware Estuary.

III OTHER PROBLEM AREAS AND NEED FOR DEVELOPMENT OF NEW TECHNIQUES

A Increasing Concern About Time Variability (Random Occurrences)

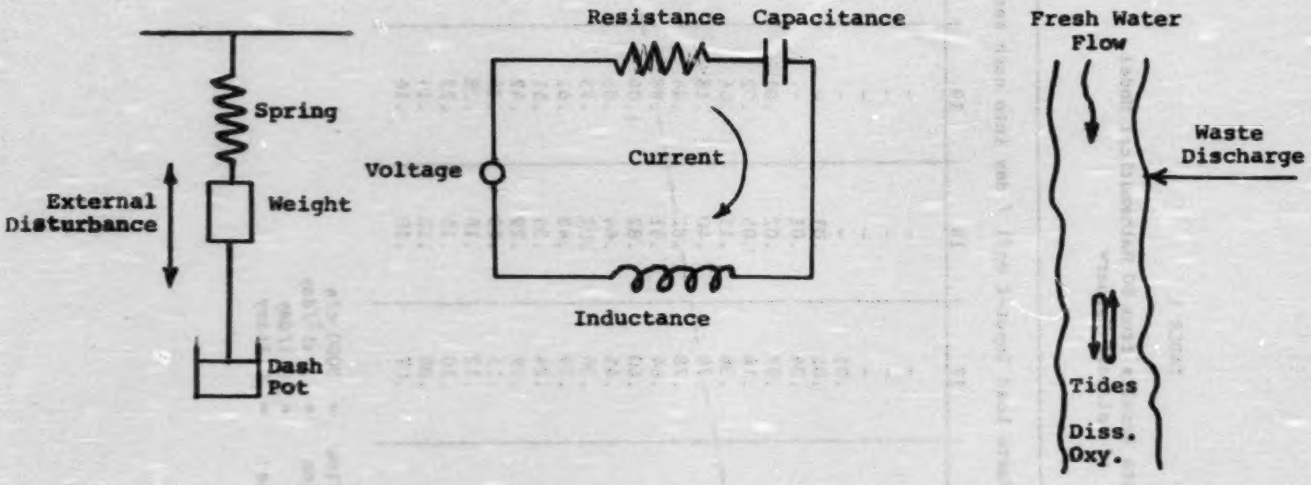
- 1 Storm water overflows
- 2 Transient meteorological conditions
  - a Wind diven currents in bays and estuaries
- 3 By-passing treatment plants and accidental spills

B Need Good Forecasting Techniques and Data Networks

C Brackish Zones and Relationship to Existing Field and Lab Testing Techniques.

- 1 Effects of salinity on standard tests
- 2 Effects of salinity on biological, physical, and chemical processes.

This outline was prepared for the Training Program by Robert V. Thomann, Technical Director, Delaware Estuary Study, Public Health Service, Philadelphia, Pennsylvania.


Spring
External Disturbance
Weight
Dash Pot
Resistance
Capacitance
Voltage
Current
Inductance
Fresh Water Flow
Waste Discharge
Tides
Diss. Oxy.

INPUT : (FORCING FUNCTION)	EXTERNAL DISTURBING FORCE	IMPRESSED VOLTAGE	WASTE DISCHARGE
OUTPUT : (RESPONSE FUNCTION)	VERTICAL MOTION OF WEIGHT	CURRENT	DISSOLVED OXYGEN
SYSTEM COMPONENTS :	MASS	INDUCTANCE	TIDAL TURBULENCE
	FRICTIONAL COEF.	RESISTANCE	FRESH WATER FLOW
	ELASTICITY OF SPRING	CAPACITANCE	DECAY & REAERATION RATES

FIGURE 1. Examples of Linear Systems

TABLE 1

Some Steady-State Results from DO Mathematical Model of Delaware Estuary

Input Section → Response Section ↓ ← Downstream DO depletion in mg/l	Waste Load Input-1 mg/l / day into each section					
	15	16	17	18	19	20
8	.01	-	-	-	-	-
9	.02	.01	-	-	-	-
10	.01	.01	-	-	-	-
11	.09	.03	.01	-	-	-
12	.16	.06	.02	.01	-	-
13	.27	.10	.04	.01	-	-
14	.44	.18	.07	.02	.01	-
15	.74	.34	.14	.05	.02	.01
16	.75	.74	.36	.15	.06	.02
17	.63	.76	.78	.40	.18	.07
18	.47	.62	.78	.82	.44	.20
19	.34	.47	.64	.81	.88	.47
20	.29	.42	.60	.82	1.06	1.12
21	.21	.31	.45	.64	.86	1.02
22	.17	.25	.36	.52	.73	.92
23	.14	.20	.29	.43	.61	.79
24	.11	.16	.24	.35	.51	.68
25	.09	.13	.19	.29	.42	.58
26	.07	.10	.15	.23	.34	.48
27	.05	.08	.12	.18	.28	.40
28	.04	.07	.10	.15	.23	.33
29	.04	.05	.08	.12	.19	.28
30	.03	.04	.07	.10	.16	.23

NOTE:
Fresh Water Flow = 3000 cfs
Tidal Diffusion = 3 mi^2/day
Decay coef. = 0.1/day
Reaeration coef. = 0.2/day

TABLE 2

Example of "Spike" Waste Load Input - DO Time Response

A Batch Dump of 1 mg/1/day into Sect. #16

DO Depletion in mg/1

Response Sect. →				Input Sect. ↓	Downstream →			
↓ Days After Dump Time	10	12	14	16	18	20	22	24
2	-	-	.02	.07	.02	-	-	-
4	-	.02	.04	.08	.04	.01	-	-
6	.01	.02	.04	.07	.05	.02	-	-
8	.01	.02	.04	.06	.05	.02	.01	.01
10	.01	.02	.03	.04	.04	.02	.01	.01
12	.01	.02	.02	.03	.03	.02	.01	.01
14	.01	.01	.02	.02	.02	.02	.01	.01
16	.01	.01	.01	.02	.02	.01	.01	.01
18	-	.01	.01	.01	.01	.01	.01	.01
20	-	-	.01	.01	.01	.01	-	-
22	-	-	-	.01	.01	-	-	-
24	-	-	-	.01	-	-	-	-

Fresh Water Flow = 3000 cfs
Tidal Diff. = 7 mi^2/day
Decay Coef. = 0.2/day
Reaer. Coef. = 0.5 (# 1-20)
0.22(# 21-30)

TABLE 3

Some Results from Least Cost Solutions for the Delaware Estuary

Waste Source	Present BOD Removal %	Problem #1 For 2 mg/l DO Minimum		Problem #2 For 4 mg/l DO Minimum	
		BOD Removal %	Investment $ 10^6	BOD Removal %	Investment $ 10^6
1	0	69	0.4	98	1.6
2	30	30	None	98	3.1
3	85	98	1.2	98	1.2
4	0	0	None	98	1.8

NOTE: Flow, diffusion, reaeration and decay coefficients are the same for both Problems.

ADMINISTRATIVE CONSIDERATIONS IN ESTUARINE ANALYSIS

I INTRODUCTION

I should like to make it clear at the outset that the views I express here are my own and do not necessarily reflect the views of the Regional Water Pollution Control Board under which I serve.

The control of water pollution involves, among other things, the placing of limits (directly or indirectly) on the quality (and in some cases the quantity) of sewage or industrial waste which may be discharged to a particular river, lake, estuary, or other body of receiving water at a given location - and in the case of estuaries, perhaps at a given time or tide. In addition, controls may be extended to include discharges onto land and into subterranean formations of one kind or another.

Regardless of how we approach the problem, however, in the final analysis the control of water pollution boils down to controlling the actions of people in one way or another - sometimes against their will. Of course, many individuals (probably a majority) are "sold" on the benefits of clean estuaries but others couldn't care less and still others believe that salt water has almost magical powers to assimilate sewage and other wastes and render such substances harmless.

II ADMINISTRATIVE PROBLEMS CONNECTED WITH ESTUARY STUDIES

With regard to estuarine analysis I shall confine myself to those studies directed at solving various actual problems rather than those concerned with pure research. It is not within the scope of my presentation to cover all the administrative problems connected with the analysis of an estuary but I shall point out a few.

As the administrator of a water pollution control program you need to obtain factual information about the estuary in order to develop a better program of control. Quite naturally you seek out some qualified scientist or researcher to obtain this information for you.

One of the first difficulties you may run into in such cases is getting the researcher to provide you with the answers you want rather than the answers he thinks you ought to have. A better understanding of each other's role is needed here.

Another problem you may encounter with certain otherwise - very - capable scientists or researchers is getting them to plan their work thoroughly in advance. You need, for the purpose of justifying your budget requests, a detailed outline of the work to be done, an estimate of the time required for each portion of it and a detailed cost estimate - including a total outside figure which is not to be exceeded. You will find, however, that some very fine scientific men are utterly incapable of planning and estimating. They want someone to pour unlimited money and effort into a research project without asking any questions. The scientist should try to realize the position of the administrator. The latter must justify his budget to others and he must report from time to time on the progress of the work. How can he do such things without adequate plans and cost estimates? Furthermore, he may, for reasons beyond his control, suffer a budget cut. If this happens (and it can and does) the question immediately arises as to what portion or portions of the work may be curtailed or dropped with the least harm to the project as a whole. Such a decision cannot be made intelligently by either the scientist or the administrator unless detailed plans and cost estimates are available.

Still another difficulty you, the administrator, may have to face is the problem of the scientist who either cannot, or hasn't the time to, direct his own staff in an efficient manner. Perhaps he has no real plan of attack, or the plan is in his head and no one else knows what it is. Eventually he puts everyone to work doing something or other, but he has no way of measuring his progress. When, or if, you suggest that a little straightening out is due, you are immediately reminded that you are not a scientist, that research work on estuaries is very complicated (which is true) that there is no precedent for this type of work and that your role is simply that of providing whatever funds are requested - without raising so much as a murmur.

There are also examples in estuarial studies where perfectly honest and capable researchers will spend unnecessary money - perhaps because they are not accustomed to handling it. For instance they will hire or purchase excessively expensive boats and other marine equipment instead of consulting with people who have a practical knowledge of such things. They will hire where it would have been cheaper to buy and buy where it would have been cheaper to hire.

They also have a tendency to rush into print, not only about what their findings are with regard to the estuary but what, in their opinion, ought to be done about the matter. In the latter case they can make things difficult for the pollution control agency whose job it is to make decisions of that nature.

Now all this may sound like an indictment of our scientific friends but such is not the case. I am sure that the scientist could point out as many or more problems which he faces with the administrator. What we probably need to do is to relieve scientists of most administrative tasks and free them for the work they are best fitted to do. We must, however, insist that even their scientific work be properly planned in advance - insofar as that is possible. We must also insist on carefully prepared and detailed cost estimates, together with time schedules and we must insist on proper supervision of the work.

III COLLECTION OF DATA THAT IS USEFUL AND CAN BE APPLIED IN:

A Pollution Control

What the administrator needs is the information and data which will enable him (or others) to compute or resolve, in a quantitative sense, the effects of waste discharges, individually and collectively, on the beneficial uses of the estuary with which he is concerned. Suppose for example, he is informed by the Department of Fish & Game that water of such and such a quality is necessary to maintain the sport fishery in the estuary and let us further suppose that the agency he represents is anxious to do just that. His problem then is to translate the desired quality of water into specific numerical limits on all waste discharges measurably affecting the fishery. Such limits may, of course, vary with season, tidal cycle, fresh water inflow, and so on but at least they are measurable. There is no question of what is meant by a numerical limit whereas words and phrases may be subject to more than one interpretation.

So far I have said that the administrator needs information and data to resolve a particular problem but I have not said what type of information and data are required to do this. Here is the point where the administrator must leave the decision to the scientist or researcher. In cases where this has been done the scientists have among other things developed detailed biological, chemical, physical, and hydrographic descriptions of the estuary with due regard for season of the year, tidal action, and fresh water inflow.

The administrator also needs a background of information and data which will constitute a base from which he can measure future progress or retrogression. For this purpose he can utilize the same material as we have just mentioned, i. e., detailed biological, chemical, physical and hydrographic descriptions of the estuary with proper regard for seasons, tidal action, and fresh water inflow. Wherever practicable such information should be placed on maps. For example shellfish areas, fish spawning areas, fish feeding areas, migratory routes, water sport zones, etc., can be shown in that manner.

Another type of useful information relates to the character of the bottom of the estuary; is it rocky, sandy, muddy, etc., and what is the nature of the benthic life found there? We need scientific appraisals and interpretations of this bottom life. For one thing it may indicate the suitability of a particular area for supporting a certain type of fishery - shellfish for example. It may also show what the area is not suitable for. Further, some biologists feel that benthic life may be used to furnish clues regarding the long term effects of pollution whereas the water itself would not be suitable for that purpose. At any rate the benthic life can be identified and it can be measured in relation to the area it covers, i. e., "quantitated." Thus, changes in benthic life can also be measured.

If practicable a "fish census" should be made in various parts of the estuary - by netting or other means. The number of fish, the number of species and their distribution should also be ascertained. I have been told this is very difficult to do but the information would be extremely useful. The fact that fish are not being caught in large numbers by sportsmen doesn't necessarily mean they are not present in the water. In this connection one should be careful not to place too much reliance on the commercial fish catch as an indicator because the number of fish caught may be influenced by the current market price - and foreign competition, etc.

The "fish census" answers the question of whether or not various types of fish are present and in what quantity. It is the supreme test (from the layman's point of view at least) as to the quality of the fishery.

B Enforcement

If your original requirements for effluent quality or receiving water quality are given in terms of numerical limits (as suggested earlier in this presentation) then your enforcement problems will be easier.

When you get into enforcement work the burden of proof is on you - as it should be under our system of government. You have to show that the pollution complained of is due in whole or in part to this or that waste discharge. Your opponents will use every artifice. They will suggest that the conditions complained of are due to some other waste discharge or to natural causes. If, for instance, the main point at issue is an oxygen depletion it may occur only during ebb tide, hence your sampling should include such periods.

We have found that our best enforcement tool is a good field checking program. A large portion of this program is devoted to securing a sufficient number of laboratory analyses and physical observations and tests to demonstrate compliance beyond reasonable doubt.

Regulatory bodies and district attorneys are more impressed with the results of laboratory analyses than they are with interesting but unproved theories. The 5-day BOD test is not perfect by any means but it has received general acceptance over a long period of time and therefore carries a considerable amount of weight for that reason.

Court action should be considered only as a last resort rather than a normal working tool but the administrator who has exhausted all other reasonable means should not shrink from court action. Once the word gets around that you will go to court if necessary, the chances are good that you won't really have to. Very recent analytical data are best for enforcement work because the discharger may claim that older data do not represent the present situation.

C Forecasting And/Or Projection

One useful product of a comprehensive estuarial study should be an estimate of the wast assimilative capacity of thc estuary under various assumed beneficial uses. For example, if we wish to preserve a good sport fishery we must strive to preserve a minimum dissolved oxygen content of say 5 ppm. If that is our goal then only the amount of DO over 5 ppm is available for waste assimilation and we can estimate the amount if we have sufficient data. I have purposely oversimplified the above example for brevity - leaving out such things as reoxygenation, inflow, etc.

A knowledge of the waste assimilative capacity of an estuary would be extremely valuable because by means of growth projection and other factors you might very well be able to show that in 10 years you will have reached capacity, even after having applied the latest treatment methods. With that sort of information available the communities presently discharging wastes into the estuary might decide it is more economical to get together and run a pipeline out into the ocean within 5 years.

It is generally best for the administrator of a regulatory agency to restrict any forecasts (or at least the public announcement of them) to a minimum. People never forget the time you were wrong even if you were right 99% of the time. It is better to leave such forecasting to the professors and scientists because if they are wrong the public will forgive them !

This outline was prepared for the Training Program by John B. Harrison, Executive Officer, San Francisco Bay Regional Water Pollution Control Board, State of California, Oakland, California.

RESEARCH PROBLEMS

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RESEARCH ACTIVITIES AT SEC - PRESENT AND FUTURE

The over-all objective of the Division of Water Supply and Pollution Control is abatement of pollution in surface and ground waters. Streams and lakes will be kept as clean as possible by maximum treatment of waste discharges to water courses and by reducing the quantity of such discharges as much as possible.

To assist in attaining this over-all objective, the SEC Laboratory of the Basic and Applied Sciences Branch (Research) is investigating problems of wastes origin, characterization, treatment and disposal, and in stream monitoring, water treatment and the supplementation and conservation of water supplied, involving analytical and instrumental needs. These studies can be grouped under the six headings as follows:

I IDENTIFICATION AND MEASUREMENT OF POLLUTANTS

A Improvement of Procedures for Recovery, Identification and Measurement of Organic Compounds

1 Carbon filter and countercurrent liquid extraction.

2 Analytical methods

Pesticides in relation to fish kills, specific identifications by infrared, paper chromatography, and gas chromatography.
Non-ionic detergents.
Odor producing organics - source, implications and efficacy of treatment.

B Recovery and identification of biological wastes.

Serological identification of fermentation wastes.

C Differentiating Pollution

Acidic components of river water and sewage effluents.

II EFFECTS OF POLLUTION ON WATER QUALITY AND WATER USE

A Requirements of Benthic Organisms

Effects of metal, pH, temperature on crayfish.

B Requirements of Planktonic Organisms

Effects of copper, cadmium, zinc, nitrogen, phosphorus, temperature on algae and diatoms.

C Requirements of Fish

Effects of temperature, pH, metals, detergents, pesticides.

D Role of Water in Transmission of Viral Diseases

Detection of minimal amounts.
Efficacy of trickling filter and activated sludge in removal.

III ORIGIN OF WASTES AND CONTROL AT SOURCE

A Land Drainage as Factor in Stream Pollution

1 Urban runoff

2 Rural runoff

B Rapid Methods for Enumerating Microbial Indicators

1 Membrane filter procedure for fecal coliforms.

2 Membrane filter procedure for fecal streptococci.

C Biological Control of Algae

1 Description of an algal virus.

IV TREATMENT OF WASTES AND CONTAMINATED WATER

A Advanced Waste Treatment

1 Carbon adsorption - 10 to 20% of weight.

2 Electrodialysis - concentration of 10-1 or more.

3 Foam separation - 30-40% removal of organics.

4 Reverse osmosis - recoveries ranged from 80-95%.

5 Oxidation - evaluation in process.

B Significance of Algae

1 Nitrogen and phosphorus removal.

2 Oxygen production.

C Adaptation of Microorganisms to Degrade Wastes

1 Shake flask tests for detergents.

2 Batch and flow through activated sludge tests.

D Ultraviolet Disinfection of Water

1 E. coli, A. aerogenes, S. fecalis, polio virus types I, II, III, ECHO virus 7 and Coxsackie virus A9.

E Removal of Suspended and Dissolved Solids

1 Removal of pesticides by oxidants, coagulation and adsorption.

F Effects of Heavy Metals on Biological Treatment Processes.

1 Three activated sludge and one trickling filter plant - effects of copper, chromium, nickel and zinc.

V DISPOSAL OF EFFLUENTS

A Use of Soils for Waste Treatment and Disposal

1 Lysimeter studies

2 Field studies

VI WATER RESOURCES MANAGEMENT

A Effects of Streamflow Regulation on Water Quality

1 Stratified impoundments.

Mixing, nitrogen balance, temperature, DO, iron, etc.

FUTURE ACTIVITIES

The research capabilities of the Division will be considerably increased with the completion and staffing of authorized field and national laboratories. It is expected that a large part of water quality criteria research will be conducted at Duluth and Narragansett. As the several field laboratories become operative, they will study problems of primary importance to their region and interests. This will allow for more intensive investigations of problems at Cincinnati that are directly pertinent to the Ohio River Basin. It is expected that investigations of some problems of national scope will be continued.

This outline was prepared for the Training Program by Paul W. Kabler, Acting Deputy Chief, Basic & Applied Sciences Branch, Water Supply & Pollution Control, SEC.

NEED FOR BASIC ENGINEERING RESEARCH

I TO APPLY A SYSTEMS ANALYSIS APPROACH TO RIVER BASIN MANAGEMENT

More specific technical information is needed to optimize solutions. Our approach to this whole problem is to try to create a feedback from the systems analysis group who will, through their preliminary efforts, be able to tell us where their needs for technical information are in the overall analysis. Any unit process work or laboratory scale operation would then be selected or guided by such a need.

II WHERE FUTURE EFFORTS SHOULD BE EMPHASIZED

A How to get more people to use the systems analysis approach to engineering.

B Determine more precisely the cost-benefit ratio for various alternatives that are to be presented to public administrators. This information is necessary in making judgments about impoundments, type of dam design and operation, and recreational uses. It will also help to point out just how much it will cost to meet a certain quality criteria.

C Tie in waste treatment accomplishments with all water needs. For instance, aim for nutrient control as well as organic control so as to retard eutrophication.

D Determine ways of economically coping with the drainage and waste collection problems of suburb and combined systems.

E Develop methods for monitoring water quality so as to meet treatment requirements automatically. This would be true of dissolved as well as suspended solids removal, and especially in relation to taste and odor problems.

F Find ways of improving the management of sludges from various sources --- water plants, storm water or combined sewer overflow retention tanks, or sewage plants.

G Continue to explore ways of keeping wastes out of streams by applying them to the soil or subsurface formation.

This outline was prepared for the Training Program by Gordon G. Robeck, Chief, Engineering Section, Basic & Applied Sciences Branch, Water Supply and Pollution Control, SEC.

NEED FOR ADVANCED WASTE TREATMENT

I Water pollution requirements will continue to increase making better treatment a necessity. Water reuse is closely allied with better treatment.

A Treatment needs to control BOD will increase.

B Non-BOD organics will require control.

C Perhaps more importantly than any of these minerals will need to be controlled.

II Biological systems can continue to be improved but needed for more assured control and treatment of minerals will be the advanced processes.

A Specific control will be needed for nitrates, phosphates, chlorides, boron, sulfate, ammonia, etc.

III Advanced treatment principles can be applied to industrial waters, agricultural run-off as well as municipal waste.

A Industrial requirements.

B Agricultural return flows.

IV Advanced waste treatment may lessen need for low flow augmentation.

A Needed is good information on a variety of processes - what is treatment capability, what is cost?

B Advanced processes permit on-off operation to advantage.

V Advanced treatment is only one segment of total solution to pollution problem but treatment capability is the last barrier between pollution and people. It should be the best that can be marshalled.

This outline was prepared for the Training Program by F. M. Middleton, Chief, Advanced Waste Treatment Research Program, Basic and Applied Sciences Branch, Water Supply and Pollution Control, SEC.

PERSISTENCE AND DEGRADATION OF POLLUTANTS

I PERSISTENCE OF WATER POLLUTANTS

A A persistent water pollutant is one which resists all forces tending to destroy it or physically remove it from the body of water it enters. A persistent pollutant does not necessarily move in admixture with the body of water it enters. It may be retained as a bottom sediment, an absorbate, etc.

B Pollutional material may be removed from water by many different channels.

These include:

1 Chemical oxidation

2 Biological degradations, either aerobic or anaerobic.

3 Spontaneous decay (radioactivity)

4 Conversion to biological material or adsorption on biological material, followed by harvesting, migration, or other processes which remove the biological material.

5 Conversion to a volatile biological metabolite such as methane.

6 Simple physical separation, or adsorption.

II WHAT IS BIOLOGICAL DEGRADATION?

A Defined here as consumption of a chemical or a group of material in life process by means which consume energy. Feeding a pig to produce a hog is an example of biological degradation. Energy is consumed, respiration end-products, such as CO_2 and water as produced, assorted partially metabolized material such as urine and feces abound, and of course, we create a very complex product, namely the hog.

B Biological destruction of energy does not have to be aerobic. Anaerobic destruction may be just as efficient in producing desired transformation of undesired material. However, the process continues to show the two characteristics of biodegradation - the process is associated with the metabolism of organisms and it yields end-products with less potential chemical energy than the parent materials. In theory, there should be advantages of anaerobic processes which relate to the fact that the rate of biological activity is not dependent on introducing oxygen into the system.

III GENERAL FACTORS AFFECTING BIOLOGICAL DEGRADATION (Aerobic)

A Temperature, seed, pH, auxiliary nutrients, other available foods, etc. Biostatic and biocidal materials, etc. The optimum temperature seems to be around 33°C for most rapid conversion.

B Synthesis and removal of synthesized material may be minimal or it may be relatively large. At one end of the operational spectrum we have operations such as those at Milwaukee which seek to make and separate the maximum amount of sludge. At the other end we have the extended aeration -- type of operation without sludge removal.

C In a stream we generally have minimal harvest; however, in the stream there are withdrawals such as fish-catch, insect hatch, and migration, bottom production or gas-like methane which is lost, stream dredging with organic material put on the shore, etc.

D Aquatic organisms can concentrate toxicants:

1 Radioactivity - (food chain of fish)

2 Pesticides (direct concentration by the fish)

IV INTEREST OF MAN IN BIODEGRADABILITY

A Biodegradability is only one of the requisites of a useful product.

B Some products have uses not compatible with biodegradability.

1 Exceptional retention, or minimum damage to economic interests of man appears indicated.

C Biodegradation may not offer any repair of harmful potential of a chemical. Organic mercurials or arsenicals would leave a harmful residue even if the organic part of the molecule were destroyed.

D Biodegradation or chemical oxidation may render a material more harmful, i.e., heptachlor - heptachlorepoxide. It is clear that biodegradation could yield intermediate products more damaging than the parent compound.

V MEANS OF MEASURING BIODEGRATATION

A Observation of evidence of microbial respiration or growth by noting evidence of oxygen consumption, by procedures such as BOD, reduction of COD, organic carbon, reduction and various types of respirometers which may measure oxygen disappearance or CO_2 development.

B Observation of the disappearance of a chemically or physically detected material or group of materials, i.e., phenol, methylene-blue active substance, 2-4'D, etc.

C Observation of change of physical properties of the substrate such as foamability, surface tension, color, odor, taste, turbidity, etc.

VI PREDICTIVE FACTORS USEFUL IN ESTIMATING BIODEGRADABILITY

A Chemical structure of carbon linkage (i.e., tertiary carbon)

B Energy relationship (i.e., carbon tetrafluoride)

C Resistant linkages and group (nitro, chloro substitution)

D High molecular weight (but cellulose can be attacked)

E Exotic linkage (silicones)

F Biocidal materials. (But many biocidal materials are vulnerable to decomposition)

G The trend to produce products compatible with proposed environmental usage.

1 The redesigned detergent molecule

2 The pressure or the insecticide situation

VII PERSISTENCE STUDIES IN THE FIELD

A The persistence study in the field consists of:

1 Study of the travel of a known contaminating material through a natural waterway (i.e., phenols, detergents)

2 Determining the polluting chemicals in an impaired waterway and studying the travel of the environmentally occurring materials down the waterway. This kind of study leads to an enforcement case, which probably will not have to be used.

a The Kanawha study

b Orthonitrochlorobenzene in the Mississippi River

B Where are we going in Field Persistence Studies?

1 Sampling improvement can extent this area, - example, countercurrent extractor, improvement of carbon extractor.

2 The improved sample coupled with improved analysis can extend this area.

3 The improved analysis for specifics can extend the area and simplify sampling requirements.

C The analytical problems above are resolved into two questions:

1 How much of chemical X or a reactive group of chemicals are present?

2 How much of what is present?

D The source of carbonaceous pollution can sometimes be resolved by carbon dating.

E The future of field persistence studies.

1 Plan to extend in terms of field studies as know-how and resources permit.

2 The need for providing samples and securing expert examination of the water polluting complex for physiological impairment.

VIII CURRENT BENCH STUDIES

A Simplified procedures for detergent evaluation.

B Evaluation of probable behavior of the new detergent. Studies of sewage treatment plant loads during the transition.

C Pesticide persistence studies.

This outline was prepared for the Training Program by M. B. Ettinger, Chief, Physics & Chemistry Section, Basic & Applied Sciences Branch, Division of Water Supply and Pollution Control, SEC.

Outline Number

PUBLIC RELATIONS IN WATER QUALITY MANAGEMENT

The Future in the Wastewater Programs 52

Improving Managerial Skills in Public Relations

The Role of Public Information in Water Quality Management 54

Professional Training to Meet Ever Changing Public Demands

THE FUTURE IN THE WASTEWATER PROGRAMS

This short discussion will be broken into two parts -- one concerning the statement of policies on wastewater control in the United States, as accepted by the Board of Control of the Water Pollution Control Federation on October 6, 1960 and revised October 10, 1963.

Basically, this policy has been very carefully worded by our General Policy Committee made up of Past Presidents, and recognizes the need for the conservation and protection of the nation's water resources through control of wastewater; also recognizing the functions of the various agencies responsible for the administration of the programs of wastewater control, and the part the public plays in sponsoring and supporting the construction and proper operation of the facilities to maintain a control of pollution.

Below is the statement of policy on Water Pollution Control.

Pollution of the nation's watercourses, coastal waters, and groundwaters is a continuing threat to the national health, comfort, safety, and economic welfare. National survival, in terms of future urban, industrial, and commercial growth and prosperity, dictates the protection of all water resources from discharges of pollutional wastes and other substances, or from any acts which cause unreasonable impairment of water quality, and adversely affect their highest level of usefulness. While considerable progress has been made in pollution control by many municipalities and industries, many water resources areas are being degraded, impaired, and damaged by such discharges and acts, and they will be further adversely affected by the degree and pattern of population growth, industrial processing, commercial expansion, chemical usages, and other technological advancements.

To Assure the Conservation and Protection of the Nation's Water Resources, the Water Pollution Control Federation Believes:

1 That the discharge of pollutional wastes into the waterways of the nation should be controlled.

2 That decisions on the type and degree of treatment and control of wastes, and the disposal and utilization of adequately treated wastewater, must be based on thorough consideration of all the technical and related factors involved in each portion of each drainage basin.

3 That the responsibilities for the adequate treatment and control of wastes to overcome pollution must be shared individually and jointly by industry and local, state, and federal governments.

4 That basic and applied research by competent personnel must be encouraged by broad mutual effort to develop new knowledge that will solve water pollution problems.

5 That the administration of pollution control must be firm, effective, and equitable.

6 That the administration of state and interstate pollution control programs should remain in the hands of state and interstate water pollution control agencies which must be supported by increased budgets and adequately staffed by well-trained and compensated engineers, scientists, and other personnel. The rights of state and interstate agencies to control and protect water resources must be accompained by equal responsibilities to perform their functions effectively.

7 That federal activity in water pollution control should be administered by the Public Health Service, which has demonstrated that it is best fitted to perform these functions by virtue of its long experience and close cooperation with state health departments and state and interstate water pollution control agencies.

8 That, while the primary objective of pollution control must be the protection of the public health, other objectives add impelling reasons for protecting, the

nation's water resources, such as the need for the use and reuse of surface and groundwaters which receive and dilute liquid wastes.

9 That wastewater represents an increasing fraction of the nation's total water resource, and is of such value that it might well be reclaimed for beneficial reuse through the restoration of an appropriate degree of quality. To this end the development of methods for wastewater reclamation and criteria for such reuse should be encouraged.

10 That the public must be made fully aware of the hazards of pollution and of the workable means for control, so that it will sponsor and support construction and proper operation of all necessary facilities.

11 That mandatory certification or licensing of better-trained and compensated operating personnel is the best ultimate means for assuring the most effective operation and maintenance of pollution control facilities.

12 That standards for radiation hazards in water pollution control should be primarily in the interest of the protection of the public health.

13 That the control of toxic and exotic chemicals should be exercised, to the maximum extent practicable, at the source in order to prevent problems in water pollution control.

14 That federal, state, and local fiscal laws and practices should be devised and modified to assure the most economical and effective means for financing the construction, operation, and upgrading of wastewater treatment works.

The second part of this discussion is some observations of the speaker. Throughout the years he has been working in this field.

A The Works

We must forget the idea that the works is simply the treatment plant, and consider the over-all phase as the works consisting of sewers, the possible overflows thereof, the plant efficiency, the loadings on the receiving body, the leeway given by the receiving bodies, and the over-all economics.

B How Far Do We Go?

Again, economics limits our constructive program, but does not limit our planning. We must all plan for at least ten years in the future if we are going to economically provide the necessary facilities for reducing pollution in the streams today. This is an absolute "must" for those who plan rate structures. As an explanation, we are now in the midst of planning secondary treatment for the large Mill Creek Treatment works approximately eight to ten years ahead of schedule, due to the raising of the Ohio River 15 feet over the old pool stage in the Cincinnati Area, caused by the construction of Markland Dam some 70 miles below Cincinnati. This nas provided a pool 98 miles long which in the summertime is almost like a lake.

Our entire concept of loading given to the Ohio River has had to be changed.

Now, to provide secondary treatment is not an easy task to participate in. It cannot be accomplished overnight -- more especially where highly industrialized waste represents a great portion of the load coming to the Treatment Works.

Even on a strict time schedule, it will be many years before the secondary treatment works can be placed in operation.

Let's take a look at timing --

6 - 9 months basic research on the type of dissolved solids waste coming into our plants to see if it is amenable to secondary treatment.

9 months to 1 year for consulting engineers to finish their feasibility report as to estimates of cost, design factors, basic layouts, etc.

3 months for approval of state and federal officials.

Approximately a 2 year construction period.

This brings the whole point of starting operations approximately to late 1969 or 1970.

I only point this out to show that you must plan far enough ahead, if you are going to be ready to operate additional facilities when necessary.

C Other Factors of Pollution

In the wastewater field we must work at all times with other factors, namely in the field of

air pollution
solid wastes pollution
agricultural pollution
boating pollution

and last, but not least, with those men providing the clean waters for use by municipalities and industry.

D Dr. Abel Wolman, Professor Emeritus of Sanitary Engineering and Water Resources at Johns Hopkins University, approximately 20 years ago at a Federation meeting stated "How far can we go economically to protect a stream?"

This is true today, as before, because each municipality is financed to the hilt and each municipality is looking for other means to get more money to carry out necessary duties to protect people in their governmental operation, to the high standards the public is accustomed to expect.

Industry, although it is working hard to remove pollutants from the streams, must carefully consider this item as an added expense to its products. It is a non-productive item in their plant.

Again we must remember that all eyes are focused on our pollution control programs. Practically every magazine you pick up -- Reader's Digest, Ladies Home Journal, Look, Life, Saturday Evening Post, etc. -- have articles on this subject, and all others are on the bandwagon to get the streams cleaned up.

All recreation people, the Isaac Walton League, the wild life groups, and even our strong Chamber of Commerce groups, our League of Women Voters, and our Jr. Chamber of Commerce groups through the country are actively participating in the program.

Let's not get off the bandwagon, but let's help and aid in any sound, economic direction the returning of some of our streams to a normal load where municipalities and industry can use and treat water economically; where people can use the facilities in certain locations for recreational purposes without having to worry about pollution effects.

As it has been said -- "Let's have the good neighbor policy." Let's remember the problem did not come about overnight, and cannot possibly be solved overnight. Let's have patience, but not too much patience, lest we become complacent. Let's take advantage of basic and applied research resources of our U.S. Public Health Service and our Universities. Let's in our treatment works throughout the country, do more applied research on a plant scale.

Above all, let's keep'em moving on trying to solve economically the pollution control problem.

This outline was prepared for the Training Program by Arthur D. Caster, Superintendent, Water Pollution Control Division, City of Cincinnati, Gest Street at Mill Creek, Cincinnati, Ohio.

THE ROLE OF PUBLIC INFORMATION IN WATER QUALITY MANAGEMENT

I Operating a program of water quality management is public business. The press (which of course today includes the air media) has the unquestioned right to know how public business is conducted. The first role of public information in water quality management is honoring this right-to-know. A second role is learning to understand what the public expects of a water quality management program and a third is contributing to the public's knowledge of the program.

This outline was prepared for the Training Program by Robert S. Hutchings, Chief, Information Branch, Public Health Service, Division of Water Supply and Pollution Control, Washington, D. C.

Outline Number

COMMUNICATION IN WATER QUALITY MANAGEMENT

Dissemination of Technical Information to the Public 56

Interpersonal Communications 57

Introduction to Specific Case Study Involving Enforcement & Technical Services Aspects

DISSEMINATION OF TECHNICAL INFORMATION TO THE PUBLIC

I WHAT IS COMMUNICATION?

A Communication is the transference of an idea from the giver's mind (the communicator - speaker/writer) to the receiver's mind (the listener/reader/viewer).

B This transfer of ideas is accomplished through the use of symbols (words/pictures).

II EFFECTIVE COMMUNICATION REQUIRES A CHANGE OF ATTITUDE ON THE PART OF THE COMMUNICATOR.

This behavioral change is necessary because of the almost universally unrealistic approach of the nonprofessional communicator.

A The change begins with facing the fact of responsibility. The communicator is responsible for the effective transference of his ideas, not the receiver.

B The change requires a realistic approach.

What is a realistic approach?

1 To see yourself in the role of the receiver instead of the giver.

2 To understand that not what is important is talked about, but what is talked about becomes important.

3 To forget what the listener ought to do, and find out what he does do, how he reacts.

4 To define realistically (this means honestly) the purpose (end result desired) of your communication:

Inform for understanding,

Inform for understanding and action,

Please the boss,

Because Washington told you to write something,

Please your vanity.

III WHAT MUST YOU DO TO ACCOMPLISH EFFECTIVE COMMUNICATION?

A You must get your listener's attention.

B You must hold his attention.

C You must be understood, not in the sense that one understands a language (English, German, Polish, French, etc.), but in the sense of getting into your receiver's consciousness, his awareness.

D Here are proved techniques for accomplishing ABC above.

1 Evaluate your audience.

2 Use the form and style of your medium and try to understand why that medium, especially a newspaper, uses its particular style.

3 Do not open with a cliche. (There is a pressing need...).

4 Use picture words (concrete versus abstract terms).

5 Talk into the receiver's experience. Tell the unknown in terms of the known. Use words (symbols) with which the receiver can identify himself.

6 Forget about "levels" of intelligence. Do not fear that you are debasing the status of your profession, or your position, to talk into the public's understanding. And do not underestimate the value of the public's understanding.

7 Never confuse talking into the receiver's experience with cheapness and demagoguery.

8 Evaluate the results of your communication. Reliable measurements are available.

And remember, barring unavoidable contingencies such as front-page murders, a stock market crash, or war, failure to communicate is not the failure of the paper, or of the reader, but of the communicator.

Seek and do not resent criticism. Accept what is valid and forget what is not. And DO NOT be upset by the adverse reaction of the few, when you are communicating to the public.

IV WHAT THE REALISTIC APPROACH IS NOT

It is not an idealistic, emotional, impossible approach, but a tested, proved, black-side-of-the-ledger technique.

V THE COMMUNICATION OF TECHNICAL INFORMATION TO THE PUBLIC IS IMPORTANT.

Consider what the world might be, and rapidly become, if people with important technical information really could reach the public.

It is my contention that any subject, any idea, can be communicated effectively to the public.

What message do you want to get to the public about water quality management?

Step No. 1. Do not open with the phrase water quality management.

This outline was prepared for the Training Program by Marsha M. Myers, former Publication Editor of the Training Program, SEC.

INTERPERSONAL COMMUNICATIONS

I THEME

"Creating understanding among people who work together."

II BASIC CONCEPTS

A The meaning of communication: exchange of ideas; sharing ideas "in common."

B The physiology and psychology of communication: method, or "structure"; message content, or "meaning."

C The nature and characteristics of the human mind: ability to think conceptually; share concepts with others.

D Attitudinal factors: individual differences; impact of differences on communication.

E Situational factors: environment, setting, "climate"; impact upon receptiveness, understanding.

F Interpretations: the significance of "meanings" derived from communicative symbols; causes of misinterpretations ("misunderstandings").

G The significance of "listening" in developing true understanding.

H Practical applications: face-to-face communications; oral presentations; written communications.

This outline was prepared for the Training Program by G. D. Thomas, Deputy Chief, Division of Career Development, Public Health Service, Washington, D. C.

	Outline Number
WATER POLLUTION SURVEILLANCE	
Introduction to Water Pollution Surveillance	
Some Examples of Unusual Data	60

SOME EXAMPLES OF UNUSUAL DATA

In the operation of the Water Pollution Surveillance System, samples arrive on schedule, are analyzed and the data recorded. In each particular unit the numbers obtained fall into cyclic patterns reflecting seasonal changes. For most samples and sample sources it is difficult to state whether or not the information obtained is significantly different from previous information. It is only by means of statistical procedures that data trends and patterns are established. Occasionally, however, samples are received in which some qualities are unquestionably different from the usual sample quality at that station.

The purpose of this lecture is to relate some of the unusual incidents of pollution surveillance and to illustrate in a concrete manner the value of the Water Pollution Surveillance System.

I BIOLOGICAL OBSERVATIONS

A The Travels of the Asiatic Clam

The Asiatic clam (Corbicula Fluminea) is a native of the Orient. In 1948 it was brought to the west coast of the United States and since that time it has become firmly established in most of the Nation's rivers. It was first observed in the Tennessee River in 1957. Three years later it had migrated up the Ohio River as far as Cincinnati.

Water Pollution Surveillance System benthos data indicate that in autumn of 1962 the clam was well established in the Ohio River at least to Huntington, West Virginia and had migrated as far as Addison, Ohio. In May, 1963, sampling at Cincinnati, Huntington and Addison revealed only dead clams.

All stations on the Ohio gave evidence that there had been a major kill of the clams over the winter of 1962-63. Sampling in late 1963 and 1964, however, showed that Corbicula was becoming reestablished in the Ohio River.

The special significance of the Asiatic clam is that it has become a pest in some areas through its prolific growth. Sheer numbers may clog water intakes and irrigation canals. The presence of large numbers of clam shells in the river bottom has been of concern to the sand and gravel industry in Tennessee.

B Asterionella as a Taste and Odor Producer

During the period April through June, 1963, the total plankton population at Yankton on the Missouri River rose to over 40,000 per ml. The diatom Asterionella was dominant during this period. This diatom is known to be a taste and odor producer. At the time of this pronounced plankton increase the city of Yankton was experiencing severe taste and odor problems. A review of this incident revealed that this was a recurring problem at the same location.

II RADIOACTIVITY OBSERVATIONS

A Strontium-90 In North Central States

Analysis of quarterly composites for the fourth quarter (August, September, October) of the 1963 water year for strontium-90 showed a very sharp increase in the north central states. A level of 11.3 pc/l was observed at Grand Forks, North Dakota. Eight of the 4th quarter composites were higher than 6.4 pc/l which was the highest Sr^{90} value ever reported by the Water Pollution Surveillance System. All of the high values were in the same general area of the U. S.

B Alpha Activity in the Ohio River

On several occasions relatively high alpha counts have been observed at Cairo on the

Ohio River. No other station on the Ohio has ever shown any unusual activity. The source of the alpha activity is not known, but it is suspected that it might be the result of leachings from coal deposits in southern Illinois.

C Alpha Acivity in the Platte Rivers

Alpha activity in the South Platte and the North Platte Rivers is generally observed to be slightly higher than most other streams in the Water Pollution Surveillance System. There is no known reason for this phenomena especially since there are no uranium mining activities on these streams. A look at a map of Colorado, however, shows that these streams originate on opposite sides of the same mountain range in a uraniferous area and the alpha activity may very well be a part of the uranium deposits in the Colorado plateau.

III SPECTROGRAPHIC OBSERVATIONS

A Unusual Occurrences of Trace Metals

By means of the spectrograph it is possible to detect and measure low concentrations of many metallic substances. In spite of the sensitivity there are some elements which are rarely detected, but are always seen in the same rivers. For instance, beryllium is consistently found in the Delaware River at Trenton and Philadelphia and in the Monongahela River at Pittsburgh, but it is never seen in any other rivers in the Water Pollution Surveillance System. Vanadium, another element rarely found in surface waters is observed consistently at Loma, on the Colorado River, but at no other station. On the other hand, lead would never be expected to occur in the waters of the St. Mary's River at Sault Ste. Marie but it has been found at this station, on several different occasions.

IV GENERAL CHEMISTRY OBSERVATIONS

A Aluminum and Fluoride in the St. Lawrence River

In the first quarter composites in 1963 a very sharp rise in the aluminum concentration in the St. Lawrence River at Massena, New York was observed. There was, in fact, an increase from 5 ppb to 150 ppb. At the same time a corresponding increase in fluoride up to 3 ppm was seen. Investigation of possible pollution sources revealed that a large aluminum reduction plant producing raw aluminum from bauxite, had installed stack scrubbers to correct an air pollution problem. The stack washings containing aluminum and fluorides had corrected an air pollution problem but in turn had created a water pollution incident.

B Sea Water at Poughkeepsie

In November of 1963 chloride values in the Hudson River at Poughkeepsie jumped from a mean of about 15 mg/l to over 700 mg/l. Not only was this a tremendous increase, it was also one of the highest chloride concentrations ever observed in the Surveillance System. Inquiry showed that the worst drought in 35 years had caused extremely low flow in the Hudson, which coupled with very high seasonal tides had resulted in sea water back-up to the sampling point, 70 miles upstream from the bay.

C Mineralization of the Shenandoah River

The mineral content of the Shenandoah River at Berryville has approximately doubled in the last 2 years. As an example, the mean SO_4 value has increased from 41 mg/l in 1962 to 90 mg/l in 1964. The yearly high has increased from 66 mg/l in 1962 to 240 mg/l in 1964. Correlary to this increase the sodium levels have risen from 21 mg/l to 65 mg/l in the same period.

The reason for this change is not known but a small industrial complex a few miles above the sampling point may be the source.

V ORGANIC CHEMISTRY OBSERVATIONS

A The Mystery Dye - Rhodamine B

In the extracts from the carbon adsorption samples a brilliant red dye, identified as Rhodamine B, is frequently found. In a systematic study of 150 carbon chloroform extracts from 50 different rivers more than half showed positive traces of the dye. Geographically, heavy industrialized rivers show the most consistent occurrences and the highest concentrations.

Rhodamine B is widely used commercially in coloring of drugs, cosmetics, inks, etc., and is used in dyeing of textiles but it would not normally be returned to water courses as a result of its use. Even though the dye is detectable at fantastically low concentrations (.0000005 mg or .5 nannograms) its presence in surface waters is a minor mystery. The detection of this material, however, is a distinct precursor of the hundreds or thousands of compounds which might be found if analytical techniques were available.

VI MICROBIOLOGICAL OBSERVATIONS

A Increasing Coliform Numbers at St. Joseph, Missouri

St. Joseph, Missouri, station no. 30, Water Pollution Surveillance System, has been showing a rapidly increasing level of human-animal pollution as measured by the delayed-incubation coliform test. Although seasonal effects on pollution are apparent, in 1964 all four seasons show an increase of 4-20 times the number of coliform organisms found in 1962:

Median Levels, Coliforms/100 ml

	1962	1963	1964
Winter	1,600	6,000	7,500
Spring	5,900	70,000	93,000
Summer	10,000	33,000	50,000
Fall	14,000	No samples	100,000

B Coliform Production in a Stream

The median coliform levels at Henry, Nebraska have ranged from 300 to 3,800 for the past four years during the winter, spring and summer quarters. During the fall quarters, however, when sugar beet harvesting and processing are occurring, coliform levels have been 10-50 times higher and, as the volume of sugar production rises, have continued to increase.

Median Coliform Level, per 100 ml

	1961	1962	1963	1964
Winter	--------- 300 - 3,800 ---------			
Spring				
Summer				
Fall	23,000	21,000	46,000	200,000

Although the coliform analysis has its basis in the assumption that increased levels normally mean increased domestic or animal waste pollution, specific circumstances such as the release of high sugar wastes may occur and cause a rapid reproduction of coliform organisms in the streams. Here, then, the levels of coliforms indicate the amount and nutritive qualities of wastes entering the stream and not the level of domestic waste pollution.

This outline was prepared for the Training Program by Robert C. Kroner, In Charge, General Laboratory Services, Water Quality Section, Water Pollution Surveillance System, 1014 Broadway, Cincinnati, Ohio

THE ROLE OF GOVERNMENTAL AGENCIES IN WATER QUALITY MANAGEMENT

Outline Number

A State Program for Water Quality Management

The Expert's Responsibility in Public Affairs 62

Federal - State Partnership in River Basin Water Quality Management 63

The Role of the Department of Agriculture in Inter-Agency Planning and Programming

The Role of the Department of the Army (Corps of Engineers) in Inter-Agency Planning and Programming

Role of the Department of the Interior in River Basin Planning 66

Role of the Department of Health, Education and Welfare (Public Health Service) in Inter-Agency Planning and Programming 67

A STATE PROGRAM FOR WATER QUALITY MANAGEMENT

One of the most serious difficulties facing water resource planning and development today is the complexity of interests and the conflicts over the use to which water will be put at a specific location. In your course to date you have heard of the comprehensive basin planning concept. You have heard of public water supply needs; from recreation and wildlife interests; from representatives of agriculture and industry; and from the technicians and scientists responsible for treatment of waste and measurement of water quality. To those of us in the water resources field it is obvious that all interests cannot be satisfied at all times. To further confuse the issue, the water resource management plan must consider the quantities and distribution of water requested and often fought for by single purpose interests. It is my opinion that the philosophy of "conservation is the wise use of a resouce" is the one which must be followed in the water resources field. Water quality management is but a small part of overall water resource management and as such cannot be considered separately, but must be considered with the whole. My remarks therefore may be critical of the efforts of some state pollution control agencies and the existing laws establishing such agencies. My remarks are intended to be constructive and it is hoped that they will stimulate some thinking toward a broad coordinated approach to water resource planning on the state level.

It is unfortunate that public awareness of resource management problems comes only when we have reached a precarious position through mismanagement or neglect. It is also unfortunate that those concerned with one effect of mismanagement will organize and promote corrective measures often to the detriment of the other problems which are just as serious. Pollution control on the state and local level has advanced to its present position due largely to early public recognition of the damage to water quality that was being caused by urbanization and by rapid industrial growth over the past thirty year period. Other fields which will materially affect water use and water quality requirements are only now being recognized and for the most part only on the national level. These include outdoor recreation, especially those oriented to water resources; the retention of rivers and streams in their natural state for the enjoyment and enlightenment of posterity; and a growing consciousness, particularly in the Eastern states, over the future quantities which will be available for domestic, municipal, agricultural, industrial, and other uses. If the principle of wise use is to be applied, future water quality management programs must be based on the political decisions which will allocate water to the several varied uses.

A review of the water pollution control laws of the states reveals a predominance of state agencies with the authority to classify waters, to set standards of water quality, or to establish standards for effluents prior to discharge to the watercourse. While it is true that standards or criteria in these areas cannot be established without public hearing, and in nearly all instances provide for later review and reappraisal, I have found no instance where the economic and social considerations necessary for determining the best use of the water must be appraised before a standard or stream classification is established. With such authority the water pollution control agency is in a position to steer the direction of the development of the state. They can by establishing rigid standards, prevent and control the location of industry, or with complete disregard for water quality requirements can encourage the location of industries known to be gross polluters within the boundaries of their jurisdiction. The hazards of centralized authority to establish standards is recognized by most state water pollution control administrators. This is evidenced by their opposition to proposals which would authorize the Secretary of Health, Education, and Welfare to establish standards of water quality on interstate streams. I do not believe that many of the pollution administrators recognize that their authority to establish standards as a state agency is just as seriously questioned by those who are interested in specific water uses.

At this point it might be well to clarify the interpretation of criteria, objectives, requirements, and standards as they are commonly used as tools in a water quality management program. A "criterion" generally designates a measurement by which anything is tried in forming a correct judgement in respect to it. A criterion carries no connotation of authority other than that of fairness and equity. It does not necessarily imply an ideal condition. Water quality criteria would be those numerical limits developed for use or guidance in the establishment of standards or objectives. Criteria are flexible in nature and should be constantly under surveillance. The word "objective" is generally interpreted to mean an aim or a goal toward which to strive, and need not represent an ideal condition. It might be set at a point too high to attain due to economic limitations. It should not be accepted as a rigid goal and should not connote the authority of a standard or requirement. A "requirement" might be considered as a decision of a regulatory body applicable to a specific location or situation. Requirements should also be considered as non-rigid and subject to change should conditions warrant. The term "standard" is usually interpreted to mean a definite rule or principle or measure established by an authority. A standard is rigid, is official, and is not necessarily fair and equitable or need it be based on sound scientific knowledge. Standards may be completely arbitrary particularly when it is deemed necessary to inject a factor of safety.

If the above definitions are accepted it is obvious that each of the terms, criteria, objective, requirement and standard implies a degree of development and establishment. A criterion may be set up by a single technical individual as a suggestion to be considered by others in developing the most desirable conditions of quality for a specific use or purpose. A grouping of individually submitted criteria would be useful in developing objectives, requirements or standards. The connotation of objectives is broader and the establishment of objectives would involve joint participation and decision by many diciplines and interests. Requirements could be established by administrative decision of a regulatory agency as a means of approaching a jointly determined objective. The requirement could be adjusted from time to time as technical capability or economics indicated achievement toward the water quality objectives. Only after considerable study and decision entered into by wide and broad interests should standards be established. Since standards assume the form of rigidity and are often quasi-legal in nature, every effort should be made to assure that it is scientifically justified and is fair and equitable. Standards should never be set to simplify enforcement action.

At this point in your considerations of water quality it should be apparent that there is a distinct difference between water quality management and water pollution control. As previously pointed out, water pollution control is a part and an important part of water quality management. It might be said, however, that water quality management is the multi-purpose approach to the problem of defining and controlling pollution to the greatest possible advantage of each water interest or use.

We should now have sufficient background information and philosophy to list those conditions that must be satisfied by an adequate water quality management program at the state level. Before any management program can be operative it is necessary that certain basic political decisions be made in order that the direction of future development be established. These decisions may never be clear cut and directed to an ultimate goal. Of extreme importance is the coordinated adjustment of each resource management program toward conformance with indicated social and economic goals as determined by the political process. Unfortunately resource administrators often do not adjust program direction soon enough to prevent inefficiencies and conflict. The water quality management program must consider each water use and each water interest in an equitable and straight forward manner. Representatives of municipalities, agriculture, recreation, industry, navigation, wildlife, power, and many others must be made to feel that they are an important part of the management program and that their desires are recognized and considered. The expanding population and industry - and the distribution of population and industry - must be projected and this must be accomplished through the joint efforts of many agencies and interests including some outside of the resources field. The optimum utilization of water resources must be determined and this again should be a political decision since it involves a comparison of economic versus aesthetic values or the measurement of tangibles and intangibles. Under the organization of many states it will be necessary to determine in detail which agency carries out which function of the water quality management program. The establishment of communications between the agencies having interest in water management will be of extreme importance and even more difficult to accomplish will be the utilization of the communication system by all involved.

Those of you who had opportunity to become acquainted with the comprehensive river basin planning effort will recognize a similarity in the approach used in basin studies and in water quality management. I will not delve further into the relationship of special interests and agencies representing those interests as that will be discussed by the other panelists.

With the understanding that the several states cannot organize and carry out identical water quality management programs due to constitutional and statutory differences, it must also be recognized that this need not interfere materially with the uniformity which is necessary if the effort of each individual state is to contribute to the national need. When the water responsibilities within state government are fragmented and assigned among many agencies and departments of government, it will be necessary to approach the water quality management program through inter-agency groups, ad hoc committees, and other such mechanisms with some leadership exhibited by the chief executive of the state. On the other hand, those states organized in a manner that places all resource management within one department must also be careful to prevent a strong interest from usurping the perrogatives and position of less popular interests to the detriment of the overall welfare. Under either extreme of organization or under any intermediate type of organization, it is believed imperative that the same basic approach be followed in the development and implementation of any water quality management program.

As a first step it will be necessary to inventory all existing water and related land and to catalog this information by use, by ownership, and if possible, by the degree of efficiency or effectiveness of the water or related land resource as it is currently used. I do not believe it necessary to keep inventories current after the initial effort. They should, however, be brought up-to-date at intervals of perhaps ten years.

A second step in the program effort is the collection of background information on existing water quality and ground and surface water interchange. Flow records should be established in a coordinated network of sampling stations. This network should be designed to permit rapid pinpointing of sources of change by river reach under future monitoring programs. Quality indices should include chemical, biological, and physical measurements.

To this point, the state program for water quality management has involved matters of scientific determination or of fact and could logically be pursued by any single purpose agency of state government equipped to carry out the investigation and prepare factual reports.

Simultaneous with these activities an economic base study which can provide a basis for making projections of use and of need in relationship to the resources should be started. This effort would involve all water resource interest and those interested in general state planning. The projections should be for both short and long range periods with any projection of over twenty years used only to illustrate trends rather than to form background for a program goal to be reached within the long range period. Efforts should be started toward the formulation of comprehensive state water policy through the political process. In order that the policy be sufficiently broad it should be developed through the joint efforts of the several state water interests followed by public hearings and adjustment, acceptance and approval of the state legislative bodies. Policy statements should be general rather than specific and should be recognized and used to guide all water and related land resource programs as well as the water quality management program. It is a policy group function to determine the relationship of the state program with the programs of other states and of the Federal Departments.

At this point the long range water quality management program can be considered in detail and assigned for implementation to a relatively compact agency or group of agencies. For continuance of the management effort regardless of organizational details each state water resource management program should provide for surveillance, communication, research, education, adjustment, and as necessary enforcement. In implementing the program it is imperative that a mechanism be provided to assure continued support from all water use interests particularly when program adjustments are being considered.

In closing I would like to point out that there are many approaches to developing and carrying out a program in water quality management. Regardless of the approach used there is one factor that must be always considered if the program is to be successful. This factor involves the tax paying public and their continued support of the program. Any state program that is for any reason justified must be understood and supported by the general public if it is to be at all effective and worthwhile. This is particularly important in the field of water resources and water resource management since there are so many diversified and conflicting ideas on the proper use of the resource.

This outline was prepared for the Training Program by Clifford L. Summers, Executive Director, Missouri Water Resources Board, 112 West High Street, Jefferson City, Missouri.

THE EXPERT'S RESPONSIBILITY IN PUBLIC AFFAIRS

Everyone seems to agree that the role of an expert (engineer, scientist, economist) in relation to government is to inform the democratic process, by using his technical knowledge and judgment to identify problems, to define choices, and to predict consequences, without making the decisions that the people should make for themselves. In other words, he is to make technical judgments and leave political decisions to the representatives of the people.

This ideal, however, is difficult to achieve. Organization loyalty may discourage the identification of a hazard to the public interest. Agency welfare and individual lack of awareness may reduce the choices presented below the number possible. Fear of being wrong or of retribution from those who feel themselves threatened may cause concealment of the full range of consequences of a proposed action. And it is sometimes hard to distinguish a technical judgment from a political decision.

The increasing complexity of government and the increasingly esoteric nature of technical knowledge interpose communication baffles between the expert and the public. Faced with the formidable task of explaining choices and consequences through imperfect channels to an ignorant public, the expert may be tempted to play doctor, to prescribe what he thinks the country needs. Since it is usually as difficult for the public to question him as it is for him to enlighten them, and because he is generally regarded, even by the courts, as being right until proven wrong, he often can get away with it.

Administrative discretion in carrying out public policy is generally held to be based on the public interest, but the public interest is often difficult to determine, especially when there are conflicting public policies. Institutional interest or personal preference sometimes seems to be substituted for, or equated with, the public interest.

It has been said that "American political action is pragmatic and expedient, rather than idealistic and principled. The political struggle is typically concerned with urgent problems and immediate solutions... Government programs thus reflect particularized responses to the demands of those who have access to points of decision." The expert at one of these points of decision finds it exceedingly difficult to examine the values and motives of the demanders; to consider the interests of those who do not have access to him; to think in terms of long-range objectives rather than expedient solutions; to design alternate ways of attaining those or similar objectives; to consider the consequences of each alternative; and, when the decision power has not been clearly delegated to him, to present those alternatives for political decision. In fact, some believe this ideal can never be achieved within the government framework.

No matter how difficult it is to do so, experts who believe in the virtue of a free society will try to present real alternatives for political decision, to explain the necessity for choosing and the consequences of choice. Freedom is defined quantitatively by the number of choices available and qualitatively by the responsibility exercised in choosing.

REFERENCES

1 Hopkin, John A. Providing for Multiple Use in the Management of Land and Water. pp 273-284 in Land and Water Use. edited by Wynne Thorne, . Amer. Assn. Adv. Sci. Publ. No. 73. 1963.

2 Kneese, Allen V. The Economics of Regional Water Quality Management. Johns Hopkins, Press, Baltimore. 1964.

3 Linsley, R.K. Some Socio-Economic Aspects of Water Development: pp 429-437 in Water Resources Use and Management. Melbourne University Press. 1964.

4 Wengert, Norman. Resource Development and the Public Interest. A Challenge for Research. Natural Resources Journal, Vol. 1, pp 207-223. 1961.

5 White, Gilbert F. The Choice of Use in Resource Management. Natural Resources Journal. Vol. 1, pp 23-40.

This outline was prepared for the Training Program by E. F. Cook, Executive Secretary, Division of Earth Sciences, National Academy of Sciences - National Research Council, Washington, D.C.

FEDERAL-STATE PARTNERSHIP IN RIVER BASIN WATER QUALITY MANAGEMENT

I INTRODUCTION

A Delaware River Basin Commission is unique among river basin agencies in the United States because of its equal rank Federal-State partnership and its authority to develop comprehensively the Basin's water resources.

B The Commissioners are the governors of the signatory states -- New York, New Jersey, Pennsylvania, and Delaware -- and an appointee of the President, who is currently the Secretary of the Interior. Each Commissioner has one vote and has appointed an alternate to handle the month-by-month policy tasks.

C Full-time staff composed of 38 employees and includes specialists in water supply, pollution control, recreation, flood control, hydroelectric power, and economics.

D Commission is financed by annual appropriations by the signatory parties.

II ORGANIZATIONAL ADVANTAGES

A Commission is in a position to promote program efficiency and economy by consolidating the plan of action for State and Federal agencies.

B Resources of State and Federal agencies available to the Commission.

C Prestige and influence of Commission in Basin enhanced by Federal participation.

III GENERAL POWERS AND DUTIES

A Comprehensive development of Basin's water resources, including water quality management.

1 Comprehensive Plan -- Will include all public and private facilities to fulfill development objectives. Currently includes:

- a 12 large multipurpose reservoirs
- b 8 local watershed projects
- c municipal water supply and waste treatment facilities
- d mainstem water quality standards.

2 Water Resources Program -- Annual statement of that part of the Comprehensive Plan which the Commission recommends for action within the ensuing six-year period.

3 Project Review -- Commission is mandated by Compact (Section 3. 8) to review all proposed projects having a substantial effect on the Basin's water resources.

- a projects must not conflict with Comprehensive Plan.
- b administrative agreements regarding project submission being negotiated with state and Federal agencies.
- c Commission approval only after all other approvals are obtained.

4 Intergovernmental Relations -- Federal, state, and local agencies directed by Compact (Article 11) to plan water resource projects in consultation with Commission.

IV SPECIFIC WATER QUALITY MANAGEMENT ACTIVITIES

A Pollution Control

1 Commission has power to establish stream classifications and waste treatment standards after public hearing.

2 May issue pollution abatement orders after public hearing.

3 Commission is requiring a minimum of primary treatment in all areas of Basin.

4 Main-stem standards more rigid.

B Alternative Programs

1 The Commission's interstate nature will enable it to explore alternative techniques for obtaining optimum water quality control such as:

- a adjunctive use of low flow augmentation
- b stream aerators
- c large-scale combined treatment plants

C Delaware Estuary Comprehensive Study -- Survey being conducted under P. L. 660 by the U. S. Public Health Service in cooperation with Commission and states.

1 Seeks least cost solution for desired water quality levels using computer techniques.

2 Needs and desires of water users being established.

3 Commission and states will be in a position to implement findings.

D Water Quality Benefits Research -- The Commission is sponsoring research at Rutgars University which seeks to establish the economic benefits of water quality to water users.

This outline was prepared for the Training Program by Herbert A. Howlett, Chief of Planning, Delaware River Basin Commission, 25 Scotch Road, Suburban Square, Trention, New Jersey.

ROLE OF THE DEPARTMENT OF THE INTERIOR IN RIVER BASIN PLANNING*

It is appropriate to review briefly the objectives or general philosophy of the statement on Policies, Standards and Procedures in the Formulation, Evaluation and Review of Plans for Use and Development of Water and Related Land Resources, approved by President Kennedy on May 15, 1962, to provide background for considering the responsibilities of the Department of the Interior in river basin planning. This will be followed by a statement on the role of the Department in such efforts as now implemented through the investigations and other activities of the eight and, in certain regions, nine bureaus and offices concerned which relate to river basin planning and as coordinated through the regional Field Committees and Regional Coordinators.

These standards clearly state that the overall objective in the formulation of plans is to provide the best use, or combination of uses, of water and related land resources to meet all foreseeable short- and long-term needs. In pursuit of this basic conservation objective, full consideration is to be given to three major concerns:

(1) development of resources as an aid to national economic development and development of each region within the economy;

(2) preservation of resources, in appropriate instances, to insure that they will be available for their best use when needed; and

(3) well-being of people. Well-being of all the people is to be the overriding determinant in considering the best use of water and related land resources.

The statement on standards requires that planning for the use and development of water and related land resources shall be on a fully comprehensive basis so as (1) to consider the needs and possibilities for all significant resources uses and purposes of development, including but not limited to:

domestic, municipal, agricultural, and industrial uses of water;

water quality control;

navigation in relation to the Nation's transportation system;

hydroelectric power;

flood protection control or prevention;

land and beach stabilization;

drainage, including salinity control;

watershed protection and management;

forest and mineral production;

grazing and cropland improvement;

outdoor recreation, as well as sport and commercial fish and wildlife protection and enhancement; and

preservation of unique areas of natural beauty, historical and scientific interest;

and (2) to consider all relevant means (including nonstructural as well as structural measures) singly, in combination, or in alternative combinations reflecting different basic choice patterns for providing such uses and purposes.

In the statements of planning objectives the possibility of conflict between the objectives is recognized. In particular, such conflict may be most intense between the goals of development and of preservation. Nevertheless, planning agencies are required to give full consideration to all objectives. When there are major differences among technically possible plans conceived as desirable on basis of consideration of intangible benefits and costs, in comparison with optimum plans based on tangible benefits and costs, alternative combinations of projects or alternative projects are to be planned and planning reports are to clearly indicate the alternatives and the consequences of the alternative plans. To our knowledge, the first effort to fully implement this injunction was the joint Interior-Army survey of the Upper Missouri River Basin. In this survey, eleven alternative plans for development of the resources of the area have been studied and all eleven were reported, including the benefits they would provide and the cost of providing those benefits. The field level report included recommendation that five alternatives be given further consideration. This variety of alternatives ranges from full development of the head of this reach of the river for hydro power production to the minimum development required to maintain the river as a wilderness waterway.

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* Paper prepared as background for participation by Henry P. Caulfield, Jr., Assistant Director, Resources Program Staff, Office of the Secretary, Department of the Interior, at the Water Quality Management Seminar, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio, on March 10, 1965. The paper was largely prepared by Miss Isabel Picken, Staff Assistant, Resources Program Staff.

The choice among plans within the Executive Branch, as well as the first choice of the Congress, is a political choice in the proper sense, that is, a choice based upon consideration of all aspects of the public interest.

The Department of the Interior is the one department of the Federal Government which is concerned almost solely with conservation, management and development of natural resources. Although there are several conservation functions for which other agencies of the Federal Government have major responsibility, it is a fact that the range of responsibilities in the conservation field which have been assigned by law to this Department is very broad. Among other things, this Department has major responsibilities in the conservation areas of fish and wildlife, recreation, public lands, territories and island possessions, Indian interests, minerals including oil, and in water resources. To some extent, all agencies of the Department of the Interior are concerned with development of water and related land resources but the Bureau of Reclamation has a major responsibility for such programs.

The activity of the Bureau of Reclamation is limited by law to the 17 western states and some activity in the new states of Alaska and Hawaii. When it was first authorized in 1902, the Reclamation program was concerned directly with the provision of irrigation water to arid public lands. The objective of the program was to make those lands suitable for settlement and thus provide an economic base for the development of the arid portions of the western states. During the 60 years since its inception, the Reclamation program has been broadened to include numerous additional functions: commercial hydroelectric power, municipal and industrial water supplies, flood control and navigation, fish and wildlife enhancement, water quality control and, in some cases, recreation. There is no general recreation provision yet, which applies to the Department of the Interior, such as that applicable to the Corps in Section 4 of the 1944 Flood Control Act. To date, recreation at Reclamation reservoirs has been authorized on a project-by-project basis. In the last six to eight years, individual project authorizations have provided for minimum basic facilities to be developed as a part of the Federal project cost with the objective that these facilities would be operated largely by non-Federal public bodies. In some cases where the reservoir is located in a National Forest such facilities are operated by the Forest Service. At reservoirs where National Recreation Areas have been authorized, they are planned and operated by the National Park Service.

In many respects, the program of the Bureau of Reclamation is similar to that of the Corps of Engineers. The notable differences are: (1) that the area of operation has been confined to the western states; (2) that the Bureau's program has been primarily concerned with functions that are traditionally reimbursable; and (3) the Bureau of Reclamation has responsibility in large regions of the country for marketing power generated at projects constructed by Federal agencies.

In addition to the Bureau of Reclamation, there are three other power marketing agencies in Interior: the Bonneville Power Administration, the Southwestern Power Administration, and the Southeastern Power Administration, each having comparable responsibilities for marketing of power in specific regions of the country. Although not responsible for implementing water resources development programs, these three agencies are directly concerned with power planning and power market studies and with the size and type of power installations at Federal dams in order to meet their responsibility for marketing the power in accordance with the requirements of law and executive orders which control their operations. In the remainder of the country, the staff of the Assistant Secretary for Water and Power Development in Washington is similarly concerned.

With the exception of the Bureau of Reclamation and the three power marketing agencies, all Interior agencies are authorized to conduct operations throughout the United States, i. e., have nationwide responsibilities. As a practical matter, the programs of two of the agencies, the Bureau of Land Management and the Bureau of Indian Affairs, are concentrated in the western part of the country. It is obvious why this is so in the case of the Bureau of Land Management, which is responsible for the management, protection, and disposal of the public lands, since most of the 467 million acres of such lands are in 11 western states and Alaska. Similarly, most of the groups of Indian people live in states west of the Mississippi River.

In neither the Bureau of Land Management nor the Bureau of Indian Affairs programs have comprehensive river basin investigations constituted a very significant portion of the total agency effort to date. In certain areas, particularly the Missouri River Basin, the Bureau of Land Management has advanced the land classification studies of the public lands more rapidly than in other parts of the country. The Bureau of Indian Affairs has placed emphasis on the problems of adjustment of Indian groups when their lands and resources will be purchased to permit construction of water resources developments. The major efforts of the Bureau of Indian Affairs program are directed toward the education, welfare of the Indian people, and management of resources on Indian lands. Increasing emphasis is being placed on improving economic opportunities for the Indian people.

Similarly, all other Interior agencies involved in comprehensive river basin investigations in greater or lesser degrees, have programs which focus on specific resources, i. e., are functionally oriented, while river basin planning efforts are essentially area-oriented. The Geological Survey, Bureau of Mines, Bureau of Sport Fisheries and Wildlife, Bureau of Commercial Fisheries, National Park Service, and the Bureau of Outdoor Recreation will now be discussed briefly from point of view of their present roles in river basin planning.

Geological Survey -- Most of the programs of this bureau, the geologic and mineral resource studies, topographic and geologic mapping and water resources investigations, provide a wealth of background information or basic data which is used extensively in comprehensive river basin planning. Programs in water resources cover a wide spectrum of activities from the basic data collection, including streamflow data, water quality data, and ground water levels, through interpretive and analytical studies of the resources to research in the various phases of the hydrologic cycle. In addition to these broad programs, which are supported by direct Federal appropriations and oriented toward national needs, the Geological Survey is requested from time to time to do specific work, usually in support of specific public works projects. A substantial amount of stream-gaging work is performed for the Corps of Engineers on a continuing basis under an agreement between the Survey and the Corps. While much of this stream gaging related to the Corps of Engineers responsibility for operation of their river basin projects, some relates to investigation activities.

On the basis of bilateral negotiations, the Survey also conducts a variety of special investigations for water resources agencies which are directly concerned with river basin planning. These include ground water studies, sediment studies, water quality studies and, in some cases, stream-gaging studies. Occasionally the Geological Survey is asked to provide a consulting service covering other phases of specialized competence, especially geologic knowledge. Such special investigations are usually funded by a transfer of funds; infrequently the Survey has been able to perform the services without charge. Increasingly the Geological Survey is broadening its studies to include descriptive and analytical studies of major drainage basins. These studies are beginning to provide the basis for increased understanding of the hydrology of river basins.

Bureau of Mines -- As the Federal agency concerned with mineral raw materials and their effective utilization, the Bureau of Mines has been increasingly involved in comprehensive river basin investigations. Mineral resource, mineral economics and mineral utilization studies have been conducted for both Corps of Engineers and Bureau of Reclamation. Factors involved in such studies include determination of mineral resources in a project area which may become developable as a result of project construction, opportunities for development of previously noneconomic mineral development because of power availability or other change in economics as a result of project construction, determination of mineral production subject to inundation or regulation due to reservoir operation, water requirements of mineral industries which may be met through project construction, etc.

The extent and type of investigations required in relation to any specific water resource development will vary widely and depend to a large extent on mineral character of the area. The problem of timing of such investigations so that information is available for the planning agency when needed requires improved coordination of effort.

Fish and Wildlife Service -- The Fish and Wildlife Service, which includes the Bureau of Sport Fisheries and Wildlife and the Bureau of Commercial Fisheries, is concerned with the impact which water resource development programs will have on the fish and wildlife resources. In accordance with the Fish and Wildlife Coordination Act, studies of the impact of such proposed developments are made and measures to mitigate damages and enhance these resources are recommended in authorization reports which are presented to the Congress for action. Such investigations and studies are made in relation to project or river basin investigations of the Corps of Engineers and the Bureau of Reclamation.

This statutory responsibility generally is exercised by the Bureau of Sport Fisheries and Wildlife. Participation in water resource planning includes such considerations as the location and design of structures; control of downstream releases to preserve or benefit reaches of stream fisheries; maintenance of reservoir water levels; land acquisition and development of wildlife habitat; and installation of fish screens, passage facilities, or other specific measures as required.

The Bureau of Sport Fisheries and Wildlife works cooperatively with affected State fish and game agencies and, when commercial fish are involved, with the Bureau of Commercial Fisheries. Fishery aspects of fish and wildlife investigations in the Pacific Northwest are conducted by the Bureau of Commercial Fisheries. In Alaska all phases of river basin analysis relating to fish and wildlife are conducted by the Bureau of Commercial Fisheries.

Many problems relating to fish and wildlife in connection with the Nation's water development program remain to be resolved satisfactorily. Passage of anadromous fishes over high dams and the return of their offspring to the sea, maintenance of sustained high quality reservoir fishing, and the very serious effects of changes in estuarine habitat on marine fish stocks are among the more pressing problems. For example, many species of sport and commercial marine fishes depend on a particular character of estuarine environment for critical phases of their development. Changes brought about by dredging, altered inflows of fresh water, and pollution are having an increasingly devastating effect. Insufficient attention has been given to date on the changes in estuarine areas which result from changes in river regimen due to water resources development and the impact of such changes on the fisheries which depend on estuarine conditions for nursery areas and growth.

Bureau of Outdoor Recreation - National Park Service -- For some years, the National Park Service has been responsible for recreation planning in relation to Bureau of Reclamation multiple - purpose planning and for recreation area planning at Reclamation reservoir projects. With the establishment of the Bureau of Outdoor Recreation there have been some changes in assignment of responsibility for such work.

The Bureau of Outdoor Recreation is responsible for the recreation aspects of comprehensive river basin planning, for assistance in recreation planning in Bureau of Reclamation reconnaissance and basin investigation and reports, and for detailed planning in relation to Reclamation project investigations leading to preparation of feasibility reports as a basis for project authorization.

The reconnaissance and basin reports on recreation developments to be prepared by the Bureau of Outdoor Recreation will include the following: evaluation of the recreation potentials of reservoir sites in terms of the demand for and supply of recreation in the state, region, and Nation; their relationship to known and projected needs, the estimated immediate and foreseeable future recreation use, estimates of benefits and losses to existing recreation values, evaluation of the kind of public use inherent in the reservoir areas, a general estimate of the amount of land needed for recreation; a recommendation as to what level of government should assume administration of recreation; and a broad overall appraisal of how much Federal funds seem reasonable to spend for development and recreation lands.

The National Park Service is responsible for the historical, archeological, and natural science aspects of comprehensive river basin planning, provides technical assistance for the Bureau of Outdoor Recreation on general recreation development planning in pre-authorization studies and is responsible for post authorization assistance to the Bureau of Reclamation on all aspects of recreation planning, development and management.

The wide range of Interior Department responsibilities in the resources field and the need for relating the functional programs of the separate bureaus and for working out conflicts among resource uses to the extent possible require that there be some formal mechanism through which coordination of efforts can be accomplished. The Department of the Interior Field Committees at field level and the Resources Program Staff in Washington have this function as one of their major responsibilities. Both are staff organizations which report to the Office of the Secretary.

The first Interior Field Committee, the Missouri Basin Field Committee, was established in 1946 (for the purpose of achieving successful coordination of the Department's program for the development of the land and water resources of the Missouri River Basin and to facilitate cooperation with appropriate Federal agencies and with State and public agencies.) Since 1946, the functions of the Field Committees have been re-examined and restated several times but this purpose continues to be one of the basic functions of the Field Committee organization.

There are eight Interior Field Committees covering the continental United States and Alaska: Alaska Field Committee; Pacific Northwest Field Committee; Pacific Southwest Field Committee: Missouri Basin Field Committee; Southwest Field Committee; Northeast Field Committee; North Central Field Committee; and Southeast Field Committee. Each of these operates in the very large region of the country indicated by its name. The Field Committee members include the regional directors or ranking regional representatives of all bureaus operating within the designated regions. They are appointed to the Field Committees by the bureau heads and their line responsibilities remain unchanged by appointment to the committees. The Field Committee members and the chairmen are jointly responsible for achieving program coordination within their regions.

The Regional Coordinators of the Department of the Interior serve as chairmen of the Field Committees. The Regional Coordinators are employees of the Office of the Secretary and report to the Secretary through the Resources Program Staff. They are departmental officials as contrasted with bureau officials and their functions in this capacity are staff functions rather than administrative. The Regional Coordinators serve, also, as the representatives of the Department on Field Inter-Agency Committees and other field coordinating committees. By virtue of their continuing working relationships with the regional bureau officials, through the field committee operations, and their direct responsibility to the Office of the Secretary, the Regional Coordinators are especially equipped to be the Departmental spokesmen at field level.

THE ROLE OF THE DEPARTMENT OF HEALTH, EDUCATION AND WELFARE (PUBLIC HEALTH SERVICE) IN INTER-AGENCY PLANNING AND PROGRAMMING

SUMMARY OF STATEMENT

The Department of Health, Education, and Welfare first became a full-fledged member of the inter-agency coordinating group in 1954 with the formulation of the Inter-Agency Committee on Water Resources. The Public Health Service has participated in inter-agency study and planning of water resources since 1938, when it made a very important investigation of the Ohio River Basin which has a significant effect on water resources development.

The Department of Health, Education, and Welfare is represented on a number of coordinating committees at the Federal level. This includes the Inter-Agency Committee on Water Resources, Ad Hoc Committee on Project Evaluation and Planning, the Research and Water Resource Subcommittees of the Committee on Science and Technology, Ad Hoc Committee on Flow Regulation, and others.

The major problem areas confronting coordinated water resource development today are legislative overlaps, budget procedural problems and timing, and differing objectives because of sponsoring interest groups.

Inter-agency cooperation has made much progress in the past two decades and will continue to improve as understanding and appreciation of each agency's responsibilities become greater. Communication through the many committee operations has greatly improved and is the key to better consideration of the plans, benefits and financing for the development of the Nation's resources.

This outline was prepared for the Training Program by Mr. Keith S. Krause, Chief, Technical Services Branch, Division of Water Supply & Pollution Control, Public Health Service, Washington, D.C.

ECONOMICS - WATER QUALITY MANAGEMENT

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NEW DIRECTIONS IN WATER QUALITY MANAGEMENT - ECONOMICS AND INSTITUTIONS*

As our resources situation and outlook has come under close scrutiny in the past several years, more and more scholars have been lead to the conclusion that our major challenge is not straightforward quantitative shortage of resources, but environmental quality problems associated with their use.** In other words, the "side effects" of intensive resources use -- especially of air, water, land and urban space resources -- have become a major source of concern. These effects which are unintended accompanyments of the main purpose of resources use can cause serious shortfalls from the level of welfare, our resources endowment and technological skills could make available, unless these side effects are optimally managed.

A traditional attitude, but one which has never exhibited itself much in behavior is that the generation of side effects -- damages from air pollution, water pollution, pesticide residuals, urban congestion -- should simply be forbidden. Since, however, side effects are costly to control, it is seldom if ever optimal to forbid them.

A classical case is discharge of waste into water courses and the side effects (or as the economist is fond of calling them - external diseconomies) associated with them. Even a rough calculation suffices to show the value of the waste simulative and transport capacity of water courses to society. Complete elimination of all waste from water courses could, over the next several decades, require an investment of several hundred billion dollars and the abandonment of millions of acres of irrigated land. Nathaniel Wollman has estimated that it would cost around $100 billion just to control waste discharges to an extent considered reasonable by conventional standards. Uncontrolled waste discharge on the other hand, would impose staggering side-effect costs in terms of physical damages, increased water supply treatment costs, and perhaps most important, lost recreational opportunities and environmental amenities. Thus, one of our major challenges is to devise an optimal balance between the valuable use of water courses for waste disposal and the external costs which this inevitably imposes.

The markets upon which we usually rely to balance the benefits and costs of resource use cannot be depended upon in this instance, simply because there are side effects which the decision-maker (industry-the municipality) frequently does not even know about and seldom if ever finds reflected in his own costs when decisions are made concerning the extent and manner of resources' use.

What have been our approaches in the U.S. to this first problem of water quality management -- optimal control of waste discharges from individual waste disposers?

We have relied heavily upon the civic responsibility of our citizens and upon law and adversary proceedings. Recognition of the limits of these devices has caused us to go beyond them to administrative regulations of waste discharges from cities and industries usually on the basis of some source of general standards. In more recent years, the Federal Government has provided financial assistance to local communities for the construction of waste treatment facilities.

I would like to comment on the economic implications of these devices -- regulation and financial support to local communities, as a means of achieving an optimum degree of waste discharge reduction.

The control of waste discharges through administrative orders regulating individual waste disposers has been a useful device. Furthermore, this device cannot be abandoned until we have a better substitute. Yet in terms of the kinds of problems we face today and can foresee for the future, regulation has its limitations. Ordinarily, regulation of individual discharges has been based on general across-the-board standards, not on a systematic balancing of benefits to downstream users and costs to the waste discharger. If the regulatory agency is to achieve such a balance in a systematic way, using the traditional tools of effluent standards, it will require extremely large amounts of information -- perhaps more than an administrative organization could be expected to secure and handle effectively. Of particular significance, this agency must know how much it would cost the water user to reduce the effluent contribution to streams by specified amounts. In other words, the regulatory agency would need to have a detailed knowledge of the costs of using water in different ways in the manufacturing process as well as of the cost of treating residual materials. Reducing industrial waste discharges into streams is not a simple question of treating waste. In addition, there are such issues as whether potential waste materials can be recovered or whether some change in industrial processes would alter the quality of the effluent. The limited information we have on such large waste-discharging industries as pulp and paper, sugar beets and canning, strongly indicates that waste recovery is often a more efficient method than treatment.*** Yet, careful examination of the technology of the industry leads to the conclusion that even now it would be possible to design a plant with no waste discharges at all. Moreover, it is almost always possible to achieve any desired level of waste load reduction more economically by process changes and waste recovery procedures than by treatment.****

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*The author wishes to express his gratitude to Irving Fox and Henry Jarrett of RFF for help in the preparation of this article.

**Cite the work of Barnett N. Morse, Landsberg, Wollman (forthcoming).

To acquire and assimilate the information necessary for evaluating these alternatives explicitly, would not only be an enormous task but it would entail a measure of public inquiry into private business activities which is not readily accepted in the United States. In seeking economical methods to reduct industrial waste loads as justified by benefits to be achieved, we are addressing an extremely important issue. The U. S. Public Health Service reports that industrial waste water effluents presently carry at least twice as much degradable organic material into U. S. water courses as the sewage effluents of all our municipalities combined. Needless to say, they carry a still larger proportion of most other types of pollutants.

Thus, I feel that if we are to cope with water pollution problems both effectively and economically, we must look beyond direct regulatory practices to new, and what some may consider revolutionary, approaches. A most promising possibility in this regard is a tax or a levy on waste discharge. This device can utilize the incentive for private gain to achieve the social purpose of reducing waste discharge in an optimal manner. Moreover, it can do this with much less information than would be needed to achieve the same end by means of direct regulation of individual waste discharges.*****

***One of the major generators of potential organic oxygen-demanding wastes is the sugar beet industry. Projecting these waste loads to future higher levels of production, some lead to astronomical figures (biochemical oxygen-demanding waste loads by the year 2,000 equal to the load of all municipalities combined at the present time) and huge implied treatment problems.

****See George A. Löf and Allen V. Kneese, Water and Waste Water Economics in the Sugar Beet Industry.

*****See Allen V. Kneese, The Economics of Regional Water Quality Management, Johns Hopkins University Press, Baltimore, 1964.

In practice, we have, to a limited degree, used a different route to provide an economic incentive to reduce waste discharge. Federal subventions to local communities have helped to improve water quality in many areas.***** It is frequently proposed in the Congress that industry be accorded some tax relief when it installs waste treatment facilities. Such financial support tends to reduce waste loads discharged, but a question arises as to whether the existing and proposed procedures produce the greatest results at a given cost.

To achieve the highest net returns from a system of financial support, the payments to the city or firm should be assigned to accomplish a degree of reduction in waste discharge which, incrementally speaking, would not cost more than the downstream benefits society would realize from such reduction. Inasmuch as water quality problems vary a great deal over the country, the most effective system of financial support would be one in which the support would vary from region to region. Also, it would be desirable that the amount of payment vary from time to time to take into account higher downstream costs during low flow periods. For example, the payment from the government should increase during periods of low flow. Also, since process and waste recovery adjustments are often more efficient ways to reduce industrial waste discharge, payments should be framed so as to take advantage of these alternatives rather than to be simply linked to treatment. The point I wish to emphasize is that if we are to make the best use of public funds in dealing with pollution, public financial support must be strategically supplied. In particular, payments should be made for waste reduction, not treatment, and geared to differences in regional situations and to the timing of stream flow.

It might be difficult, of course, to obtain agreement on a system of this nature. Also, establishment of an ideal system of subsidies presents some difficult administrative problems that are to be avoided by a system of charges or taxes with the same effects on water quality. Moreover, many members of both political parties have become quite cognizant of the perverse and distorting effects of the existing tax structure. To load that structure further through additional subsidy measures or further erosion of the base as would occur if any of the various proposals for rapid tax writeoffs of pollution reducing material were to come into existence, can only increase these difficulties. The tax or charge on effluents has a firm theoretical foundation. There is every reason to believe it will work in the direction of lessening the distortion and resource allocation caused by the side effects of water resource use, while at the same time yielding revenue which can be used for various public purposes, thereby lessening pressures for taxes which are known to have perverse effects. Among the purposes to which the revenues resulting from this charge could be deroaded is the improvement of water quality to various large-scale collectively provided measures. I would like then to turn to the second aspect of the problem of water quality management, the optimum provision of large-scale collective facilities for water quality improvement.

As already implied, frequently public or collective agencies can do more than provide the proper level of incentive for reducing waste discharge by industries and municipalities. This is the case when collective facilities like reservoirs, treatment in the stream itself, or treatment of waste transported to a collective plant are economical alternatives to waste reduction at the individual outfall. Thus, low flow augmentation to provide dilution water is an appropriate technique for helping to maintain water quality in an overall system of water quality management. However, if we are to achieve desirable results at a minimum of cost, the cost of low flow augmentation must be compared with all the relevant alternatives for achieving the same returns and then the lowest cost technique selected.

*****The Federal Water Pollution Control Act, 62 statutes 1155 (1948), 33 USC, paras. 466-66K (1958), amended 1961, 75 statutes 204, authorized grants to municipalities for construction of sewage treatment works. A grant of 30 percent of the estimated reasonable cost of construction, or $600,000 whichever is less, may be made for a single project, and a joint project to serve two or more communities may receive $2.4 million. Federal funds authorized to be appropriated for this are currently $100 million per year.

Present institutional arrangements in general do not provide an appropriate mechanism for the identification, evaluation and implementation of the appropriate range of alternatives, including collective treatment of waste, measures for improving water quality in the stream, stream specialization, as well as low flow augmentation. Indeed, the only alternative to treatment explicitly recognized and consciously examined in present federal agency practice, is the augmentation of low stream flows. Thus, we do not have the framework of an overall system in which other alternatives are fully and flexibly considered. I would like to comment a bit further on this matter.

It is existing policy to provide flow augmentation for multi-purpose federal reservoir projects on a non-reimburseable basis provided certain specified standards of treatment are met. For municipal wastes this is interpreted to be so-called secondary or biological treatment. In the case of industry, where the notion of secondary treatment is frequently not very meaningful in view of the character of the wastes involved, the treatment required is that level deemed "adequate." Several points may be made concerning these policies and the likelihood that they will actually result in a least-cost combination of flow augmentation with other alternatives.

First, the secondary treatment requirement for municipal wastes and the much more vague "adequacy" requirement for industrial wastes are essentially arbitrary -- they do not result from a weighing-off of comparative costs. This may be justifiable as a matter of administrative convenience in the absence of resources to make systematic studies, but in terms of precise economic management of water quality, it must be deemed an arbitrary restriction.

Second, there is no provision in the federal procedures for a systematic identification, evaluation and balancing off of other alternatives such as collective treatment of wastes, direct reaeration of streams, provision of retention ponds and streams to produce waste degradation, artificial recharge of ground waters to improve quality before use, etc.

Third, the non-reimburseable feature of present policy does not provide an appropriate incentive for the use of alternative methods of controlling waste discharges into streams. Unless waste dischargers, particularly industry, must bear the cost of providing low flow augmentation -- a cost that can be avoided by reducing waste discharge -- they will not tend to substitute alternatives such as process adjustments and byproduct recovery in appropriate measure. It is true that attempting to assess waste dischargers with the cost of flow augmentation would entail an additional administrative cost, but especially in highly developed basins this may prove richly worthwhile in terms of the increased efficiency achieved.

Fourth, it is important to realize that non-reimburseable features of federal programs lead to pressures tending toward inefficiency. If beneficiaries of a program bear none of its costs, they will favor it even though it is in fact worth less to them than it costs. Also, they will tend to favor it over less costly alternatives for which they have to bear the cost. Let me just illustrate how such pressure could arise. The Corps of Engineers is proposing a costly system of reservoirs in the Potomac Basin whose primary function is to dilute the waste at the Washington Metropolitan Area. It has been suggested that a less costly alternative would be to conduct the treated wastes of the area by pipeline to the Chesapeake Bay where copious amounts of dilution water are naturally available. Let us, for the sake of argument, grant that that is the case. The Washington Metropolitan Area would then have to bear most, if not all, of the cost of the more efficient alternative and none of the cost of the less efficient one. Thus, an incentive is given for beneficiaries to favor the alternative which is financially less expensive from their point of view, but which in fact is socially more costly. The conflict between socially efficient and locally advantageous decisions is particularly serious if we wish to use regional agencies for water resource management to a more far-reaching extent -- a possibility which I will shortly suggest merits serious consideration and experimentation.

In recent years, public agencies, both state and federal, have made substantial progress in dealing with the pollution problem. However, my brief examination of existing approaches to pollution abatement reveals that there are inherent limitations in the techniques upon which we have relied. The limitations of these techniques may be summarized briefly as follows:

(1) For direct regulation of individual waste discharges to be fully effective, the regulatory agency would require a knowledge of economics of water use within the individual plant which would be difficult to obtain as well as to utilize effectively.

(2) Federal financial aid is not as effective as it might be because it is not geared to different regional situations and different stream flow conditions.

(3) Low flow augmentation policies offer an incentive to use this technique as opposed to alternatives which may be more economical but which are not eligible for federal financial support.

(4) The industrial firm disposing of wastes to streams has no systematic economic incentive to adopt industrial process changes, including byproduct recovery, which might result in substantial reductions in waste contribution when these processes involve a lesser cost than the side effects they tend to produce.

(5) We have generally not evolved arrangements for realizing the economies of large-scale treatment and management of waste disposal. It is evident that large plants which will process the wastes of a number of communities or plants often will be more economical than individual waste treatment facilities. Also, there are substantial economies to be realized through development of regional waste disposal systems which utilize alternatives such as the direct improvement of water quality in the stream, the specialization of streams, diversion channels for wastes and a whole host of other possible alternatives.

(6) Present procedures are not well adapted for day-to-day, well-articulated operation of waste disposal facilities in a region as a whole. In many instances, this is fully as important as finding an efficient system in the first place.

I do not mean that precise, optimizing approaches would necessarily be appropriate in all areas. It is, of course, essential that attention be given to the costs of implementing such approaches in the various regions, in some of which points of pollution are scattered and more systematic approaches do not yield large dividends.

It should be noted, however, that already some 40 percent of our urban population and a higher portion of our industrial activity is located in only four of our 22 major river basins. These basins frequently contain huge meglopolitan complexes and intensively developed watersheds where the gains from systematic approaches are likely to be large.

Accordingly, it is my strong conviction that in our more heavily populated industrialized regions, we should move toward the creation of regional agencies with far-reaching powers to plan, construct, operate, and finance regional systems of waste disposal; but emphasis should be made in these organizations on the use of effluent charges to control waste loads delivered to the system and to provide the financial support for large-scale efforts deemed at improving water quality to the extent that incremental benefits are deemed to exceed incremental costs.

Along this line, I should like to comment on the situation in one area of the world where problems of the intensity we are beginning to face in the United States have existed for a long time and where they have, in my view, been effectively and efficiently handled.

Water Quality Management in the Ruhr Region of Western Germany

Elsewhere, I have published a case study of water quality management practices in the Ruhr region of Germany.******* The Ruhr region is approximately half the size of the Delaware River Basin. The streams which serve it have a very low flow during the summer season. It is approximately one-quarter of the lowest flow ever recorded on the Delaware River. The population of the area is around 8 million and it is perhaps the world's most heavily industrialized area. Forty percent of the industrial production of Germany occurs in this region, including over 80 percent of the heavy industrial output. Because of the density of population and enormous industrial output, the waste disposal demands within this region are large indeed. Yet major sections of the Ruhr River are so managed that the river itself is suitable for recreation purposes including swimming and boating. Moreover, prices of unsubsidized publicly supplied water are the lowest of any of the major urban areas of Germany. I will not go into detail about how this result was accomplished. However, the following features of the arrangements which have been utilized there are central to the success of these organizations.

(1) The system that has developed has been specifically designed to meet the needs of the Ruhr region. It is a unique system within Germany.

(2) Waste disposal is managed on a region-wide basis in which advantage is taken of economies resulting from flow regulation and large-scale treatment and recovery of potential waste products. The regenerative capacity of the streams is utilized to the extent consistent with water quality standards which are based on a variety of water uses in the area.

(3) One stream in the region is used in a completely specialized way being dedicated to waste disposal use only.

(4) Industries and cities pay a charge for the effluent they contribute to the waste disposal system based upon periodic tests of the quantity and quality of their effluent. The charge which is levied is not contingent upon whether the wastes are directly handled in treatment plants or not. This independence of effluent charges from the provision of specific facilities is essential if potential gains in efficiency from system design are to be realized. This can perhaps best be illustrated. Economies of scale and treatment may mean that wastes from Factory A are given far-reaching treatment because it has a large effluent volume and costs per unit of waste removed are comparatively low. Say Plant B has only a very small effluent volume and treatment would be very expensive. Desirable (cost minimizing) stream conditions may be attainable by treating only Factory A's waste at low cost and not treating B's at all. If an appropriate method of assessing costs exists, part of the cost will be paid by B and both A and B can benefit because total costs are lower than they would be if the same result had been achieved by two smaller plants. The Ruhr Area Association has worked out rather sophisticated cost assessment procedures along these lines.

The results that have been obtained in the Ruhr region are impressive. The system of effluent charges is a particularly effective means of motivating industries to minimize the contribution of their waste to rivers. The firm decides on the basis of the schedule of charges the extent to which it should treat its wastes or alter its industrial processes to minimize costs. The administrative agency decides upon a level of charges consistent with what it considers to be the cost to society of dealing with a given quantity of wastes.

It would seem appropriate that we begin moving toward regional systems adapted to the needs of particular regions in the United States. A start has already been made on this. The Delaware River Basin Commission

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*******See Chapter VI of Allen V. Kneese, Economics of Regional Water Quality Management, Johns Hopkins Press, 1964.

has the authority to experiment with new techniques and devices for dealing with the pollution problem and the obligation to plan and implement systems of water resources management tailored to the Delaware region. Further institutional development along these lines might well be carried on in smaller river basins within individual states where the difficulties attendant to the formation of interstate compacts with far-reaching powers are not an obstacle. The more highly developed tributaries of the Ohio suggest themselves as likely candidates for instance. Full scale development of regional approaches to the water quality problem using relatively sophisticated and precise techniques of management are probably contingent on certain help at the national level, however. In the final section of this paper, I outline some possible national policies which would help to lead toward the objective of forming competent regional agencies.

Some Possible National Policies Encouraging Regional Water Quality Management

A successful program of regional approaches toward water quality management will probably depend upon some national policy changes which would encourage the development of regional agencies, both by removing existing obstacles and by providing positive aid. One possibility would, of course, be for the Federal Government to take direct action. It could set up regional water quality management agencies or overall regional water resources agencies with water quality management responsibilities. These could be separate entities such as TVA or units of a regional authorized federal agency such as proposed by the first Hoover Commission. There has been much opposition to arrangements of this nature and even if it should be deemed desirable which seems quite doubtful that the Federal Government would be willing to move in this fashion.

An alternative would be for the Federal Government to establish incentives for the organization and operation of regional agencies either under state law or through interstate compacts. Such incentives might be provided in the following manner: Upon creation of an agency with adequate authority to institute an optimizing system, the agency would be eligible for a grant of funds to support a share of its operating costs while it assembled and analyzed pertinent data and designed its specific program. If the Federal Government is satisfied that the proposed program would meet reasonable optimizing objectives, the agency might be eligible for a grant to assist it with its operating expenses. Such assistance might appropriately be limited to the implementation period -- such as five years. The regional agency might also be made eligible for federal loans for investment in large-scale facilities where scale economies can be achieved. If the regional agency has general water resources development and management responsibilities -- as seems highly desirable -- Federal Government could provide support through the Agency for Flood Control, Navigation, Irrigation, Power, and Recreation Facilities on the same terms as such support is provided through the federal agencies. Unless this were done, regional agencies would operate at a serious disadvantage and it is doubtful that regions would willingly impose such disadvantages upon themselves. A partial or complete alternative to the extension of subsidy arrangements to regional agencies would be a concerted effort to impose the cost of federal agency water programs upon beneficiaries.

Finally, and perhaps most importantly, the Federal Government could establish a policy of levying charges or taxes upon effluents. This would not only be a tax with a strong theoretical justification but might be used to eliminate the relative disadvantage under which regional agencies levying charges would otherwise labor. Once a regional agency were duly established the authority and responsibility for levying the charges could be turned over to it. The regional agency could refine the system of charges as a tool of management since in areas without regional agencies having continuing responsibilities for water quality management the tax might, for administrative reasons, need to be based upon rather crude rules of thumb and self-monitoring by waste dischargers. In both cases, however, it would be very important that

assessment be made in such a way that the waste discharger could reduce or avoid the tax by reducing his waste discharge, otherwise the incentive effect would be lost.

For the established regional agency, the charge would provide a source of revenue which could be used to operate a system making full and flexible use of the full array of efficient means for dealing with the problem.

If we are to develop management tools and skills commensurate with the increasingly challenging problems of environmental quality we confront, bold thought and imaginative experimentation are fully as essential in the realms of economies, institutions, and laws as is science and engineering.

This outline was prepared for the Training Program by Allan Kneese, Resources for the Future, 1755 Massachusetts Avenue, Washington, D. C.

PUBLIC RELATIONS ASPECTS

PURPOSE:

To show government can gain public understanding and support in order to effectively exercise its responsibility in water control management.

THESIS:

An effective public relations program is needed to help government obtain the public support it requires to exercise its function in water quality management.*

I Industry and the public share a joint responsibility for wise water management.

A Private industry creates most of our pollution.

  1 Business is properly concerned with developing the least expensive method of pollution control.

  2 Industry cannot continue to expand unless it has enough water, and its costs increase in proportion to the poor quality of water it takes in for manufacturing purposes.

B The public stands to benefit most from good water management.

  1 Our future economic well being depends on the ability of industry to expand.

  2 Public health demands a safe source of water for home consumption.

  3 Families need more and better recreation facilities.

II Government is responsible for water control management.

A It has the legal right to exercise control on various levels of pollution, navigation, conservation and recreation.

B It is the only medium through which the large amounts of public money required for these functions can be raised.

III Legislation is not enough in developing effective water control.

A No unit of government in a free society can function effectively unless it has the financial and moral support of the people it is organized to serve.

B Such support depends on public recognition of and willingness to solve broad problems, such as water control.

C Until the public understands more keenly the problems and benefits involved here - and the remedies necessary to solve them - effective water control and management will continue to lag.

PART TWO:

A General Discussion and Program

I Emphasize what good water means to people.

A Better jobs, a better standard of living.

B Family health protection and increased convenience in the continued use of labor saving appliances such as garbage grinders, washers, and ample quantities of water for general home and garden use.

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*See outline by author detailing a specific public relations program (November, 1960).

C More fun out of life through better fishing, swimming, boating and a contribution to a more harmonious balance in nature.

II Show clearly how pollution and poor water management threaten the above benefits.

A Stress local conditions which illustrate good and bad examples of water management.

1 Industry lost to other communities because of inadequate or polluted water.

2 Recreation areas ruined by polluted or inadequate water supplies.

3 Other

B Try to establish an individual identification for the people or communities concerned: "This affects me," is the only reaction that moves people to action. Everyone is against pollution in principle, but how many people vote no when money is required for new treatment facilities, trunk sewers, etc.?

III Strive for cooperation between industry and local units of government responsible for pollution control.

A Industry recognizes that it cannot continue to pollute indiscriminately; it now is in the position of looking for the cheapest way out.

B Because it is aware (at least generally) of its responsibility in causing pollution, industry is naturally wary of controls which it has not had a hand in shaping.

1 Keep industry informed.

This outline was prepared for the Training Program by T. Sperling, Mutual Fund Manager, Fusz-Schmelzle & Company, St. Louis, Missouri.

PROMOTING A SUCCESSFUL BOND ISSUE

FORWARD

Lack of sewerage and water facilities is the most neglected of all public works problems. Its solution is hampered by fierce competition for the public tax dollar and, therefore, must depend on the ability of public health officials and informed, aroused citizens to stimulate their local communities to supply the necessary money - basically through bond issues. Passing these bond issues involves the employment of effective, well-thought-out public information techniques by representative citizens groups aided by public officials and guided by professional public relations counsellors.

I ORGANIZATION

A tightly-knit group should function as an organizing and steering committee in order to set policy, raise money and steer the progress of the campaign.

A Start with a small group which should be considered the nucleus of a future larger organization.

B Make the small group responsible as the organizing and steering committee and for raising the initial money for the campaign.

1 Since money must be raised privately, the committee must have a definite idea of how much it will require before the campaign or solicitation begins.

2 Financing for a particular campaign may vary from several hundred dollars to as much as $30,000 or more.

C Preliminary Planning and Fund Raising

1 Always ask for money in lining up initial support. Most persons will refuse, but by so doing, will have to commit themselves to some other active participation.

2 Committee members soliciting funds should concentrate on individuals and organizations which - on the basis of previous experience or community relations - will be most likely to contribute. Included in this group are: banks; all utilities, especially railroads, gas and electric; realtors and/or contractors; improvement associations, etc.

3 After initial planning, enlarge the steering committee to include a wider range of key people for major committee posts. They, in turn, should be capable of bringing in more key people as the need arises.

II OVERALL PLANNING

A Overall planning needs to be done by the steering committee before it enlarges its numbers, since assistance is more easily gained by showing prospects a blueprint into which they might fit their particular talents.

B Obtain and be willing to pay a fair price for professional public relations help. Since it is paid for what it knows, give that professional consultant a strong voice in initial policy decisions.

C There is no substitute for effective organization. There is no such thing as effective organization without a firm, well-thought-out, sharply-timed master plan.

D Think out and emphasize key points to be sold.

1 Individual Health Protection (Make people compare the cost of the improvement with what they would have to pay for doctor and hospital bills if an epidemic disease were to strike.)

2 Community Benefit. (In addition to the obvious points, focus attention on how

the tax base eventually may be spread to lower taxes generally if the improvement goes through. This is done by making trunk sewer, treatment and water facilities available so that investment capital will be attracted to the community to invigorate and achieve a balance of industry, business and residential development.)

3 Outright fear of disease and the possibility of epidemics.

4 Locate and nail down an alternative to the bond issue so that the alternative will loom as an example of what will have to be done in case the bond issue fails.

5 Sell the advantages of the particular type of bond issue. If revenue bonds, promote the point that there is no tax, but a service charge shared by all who use the facility. If general obligation bonds, point out that all property owners who move into the community over a 20 year period will have to share the cost. Most important is g. o. bonds: Emphasize that the tax rate must go down as the assessed valuation for the entire bonding area goes up.

E Be careful in selecting an election date and the timing of publicity

1 Election dates should be when the problem is the worst, summer - for example - for trunk sewers, and the most favorable for the success of the bond issue.

2 Make certain the election date is during a period when plenty of citizen help will be available. (Will vacations or other important activities interfere?)

3 Beware of unseen obstacles. An election date coinciding with the receipt of annual tax bills could be catastrophic; avoid the time of month when charge accounts are billed and received.

4 Generally, it is preferable to wage an intensive campaign rather than one which is extended over many months: 30 days is an absolute minimum; over 60 days is dangerous.

F Liaison is important. Make certain that key people meet often enough and consult with the public relations people. This will avoid time-consuming delays on decisions which only the committee may make, but which inevitably crop up when least expected. Key people must make decisions quickly or valuable time and initiative will be lost.

III THE CAMPAIGN

A Money and Expenditures

1 It will be required for telephone and office; postage; printing; movie; photos; print advertising; engravings and mats. It will not be needed for: feature stories; news coverage; TV and radio spots.

2 Make certain a responsible treasurer is appointed and that a firm budget is submitted and administered by the public relations counsel and committee.

B Media

1 Newspapers may be counted on to publish the following items submitted by the committee: news stories, photos, feature articles, letters to editors, editorials. These are released by the public relations counsel according to pre-determined timing and strategy.

2 Television may be used for two basic purposes:

a 20-, 30-, and 60- second spot commercials prepared by the committee and run as public service by the stations and their own programs by public-minded sponsors such as banks and utilities.

b Public service, panel-type discussions and/or debates, usually incorporating all or parts of the film produced for the bond issue (if a film is possible within the budget).

3 Radio is treated exactly as television.

4 Motion pictures should be produced to tie in easily to 15- or 30- minute TV shows. This means films about 13 minutes long or 24 to 28 minutes long.

a Movies should not be expected to "sell" the bond issue. Their basic purpose is to acquaint large numbers of people with the problems and solutions.

b A professionally-produced movie will cost $3000 to $5000. Amateur movies may be used as long as the script does not call for technical accomplishments beyond the scope of the skill and equipment of amateurs.

c Have enough copies of the film available so that TV stations may cut up and edit for news shows and special events.

d Educate speakers for the bond issue on the use of the projector; obtain enough projectors for simultaneous showings before various civic groups, PTA's, etc.

5 35 mm. slides offer a fine, low-cost substitute for a film and are extremely effective in illustrating the problem to be solved by the bond issue.

a Shoot several copies of the same scene in order to provide enough pictures for the several speakers.

b Develop a specific talk built around the slides. Rent or buy sufficient projectors, but be sure to utilize sleeve inserts into which the slides first are put in specific order. This eliminates any worry of the speaker mixing up the rote of the slides, and will give him visual aid in presenting his prepared talk.

c Render all maps and diagrams on 35 mm. slides. Small copies on easels are useless before a crowd.

6 Bus tours and in-plant visits convert opponents or disinterested citizens into "yes" voters.

a Bus tours should begin at a shopping center or some other easily-found point.

b The group leader should give a 10 - to 15-minute orientation talk before the group boards the bus. He should explain what will be seen on the trip and why, and should distribute printed material in advance which can be consulted on the bus or during the tour.

7 Direct mail is a very effective tool if used properly.

a Always be specific and to the point. Do not try to sell everything in one mailing piece.

b Consider printing post cards which may be signed by proponents and mailed to their friends.

c Always have a final mailing which will reach the voter the day before the election. (A weekend is good if the date for election is early in the week). Always include a sample ballot which has been marked "yes", and a brief, strong resume of the points for the proposition.

8 Testimonials should be developed from doctors and community leaders, but also from persons who are not "big wheels" throughout the community. Never overlook the big fish in the small pond.

C People

People working for it are by far the most important factor in the success or failure of a bond issue. A well-organized, devoted group of interested citizens is worth far more than the total of money, advertising and news coverage. However, workers must be inspired by the committee and supported by the overall objectives of the compaign.

1 Speakers

a Educate them together in a well prepared, illustrated program.

b Avoid committing lay speakers to technical points. Have a competent technician accompany him and answer such questions.

c Provide visual aids (see section pertaining to 35 mm. slides and films).

2 Block workers

a Develop a city-wide (or district-wide) master plan so that each block is covered by a responsible worker who will report to a district captain. Make sure block and district workers are kept constantly in touch with the campaign and its objectives before the general public is informed. This may be done at occasional group meetings.

b Consider enlisting political precinct workers through the township committeeman only if sufficient funds are available for such work. Do not overlook this source just because it is political in nature. Usually, only registered voters are eligible to cast ballots; precinct leaders often get results.

3 Civic clubs

a Enlist the active support of PTA's; Kiwanis, Rotary, etc.

b Be especially cooperative with the Junior Chamber of Commerce and other such organizations which have young adults as members; they tend to be the most active.

4 "Blitz Crews" on Election Day

Utilize supporters of the bond issue for an all-out effort on election day: actually organize a giant "blitz squad" to literally pull in votes election day. Here is how:

a Prepare a map in advance showing all precincts and wards. Post it election day at headquarters. Appoint three experienced people to analyze and record the number of the highest votes during the last general election. Then, prepare a cross reference of these results for each precinct or ward on the map.

b Have couriers visit each polling place once every two hours to obtain the total number of votes cast up to that time. (This is perfectly within reason and is not frowned upon). Couriers relay this count to headquarters, where results are posted for each ward or precinct on the master map... for the specific time of day. Keeping in mind that the vote between 4 p.m. and 7 p.m. will be at least twice as heavy as the vote from 6 a.m. to 4 p.m., analyze the courier reports every two hours and...

c Assign mobile blitz squads to drive into the areas in which the two-hour vote tally indicates the vote is lighter than it should be. These couriers distribute literature and knock on each door on a block-to-block basis within that ward or precinct. They offer rides to the polls immediately and, in short, do their best to convince the registered voters within to accompany them to the polls immediately. In the process, they almost always will pull in "yes" votes.

IV POST CAMPAIGN ACTIVITY

A Have a victory and defeat statement prepared in advance, each premised on policy the committee has agreed upon before the election.

1 If victorious, be certain everybody concerned publicly gets credit.

2 If defeated, have the committee meet immediately to discuss policies to be recommended in view of the defeat.

Just as no modern army would enter a battle without alternative plans of action - should it meet temporary set backs - so no bond issue campaign ever should overlook the necessity to plan in advance for the possibility of defeat.

B Maintain community interest after a victory by keeping events relating to the bond issue (ground breaking etc.) before the public.

This outline was prepared for the Training Program by T. Sperling, Mutual Fund Manager, Fusz-Schmelzle & Company, St. Louis, Missouri.

CONSTRUCTION AND OPERATING COST FOR WASTE TREATMENT PLANTS

I INTRODUCTION

A The desire to own something must be supported by the ability to own something; therefore, knowledge of the initial cost of the commodity, and the cost to operate, maintain, and protect the commodity throughout its useful life are essential to a prospective owner in order that he may determine if he should proceed with its acquisition.

B Actual costs unfortunately are not available until after the fact, yet, preliminary costs must be determined before a project can be undertaken.

C In order to provide estimating guides so that more reliable preliminary cost estimates could be made, or evaluated the Public Health Service has pr pared a series of publications and guides dealing with construction and operating costs.

II MODERN SEWAGE TREATMENT PLANTS - HOW MUCH DO THEY COST? PHS Publication #1229

A This is the current report of an investigation originated in 1958 into the construction cost of Municipal Waste Treatment Plants.

1 Earlier cost studies (cited in references):

a Restricted geographic areas.

b Restricted forms of treatment

1) Gross type of treatment; i.e., primary, secondary and lagoons.

c Less comparable time/cost relationships

d Smaller statistical base (20 to 500 ±).

e Limited design criteria (population served, flow or population equivalent).

2 Current cost study:

a Based upon contract costs for over 1,500 municipal waste treatment plants.

b Estimating curves were developed on basis of population served, design flow, and design population equivalent.

c Geographic and time/cost differences reduced through the use of an index developed for this specific purpose.

B Mechanics of Analysis:

1 Basis of the study were all new sewage treatment plants which had received grants under the incentive grants program and placed under construction contract prior to 1964.

2 Cost data was obtained from the actual construction contracts. In those cases where costs between the plant proper and interceptors, outfalls, and pumping stations not adjacent to the site could not be identified, the projects were excluded.

3 Design data was obtained from the preliminary engineering report and verified by the design criteria used in final preparation of construction plans and specifications.

4 The cost data was reduced to unit costs on the basis of cost per person served, cost per unit of flow per day, and cost per population equivalent served.

5 Using the Sewage Treatment Plant Construction Cost Index, all cost data was corrected to a theoretical common geographic location expressed in 1957-1959 dollars.

6 The cost data was then grouped by type of treatment provided, and estimating curves and their equations were calculated on the basis of cost per unit versus units.

7 Costs for administration, engineering, legal and fiscal services were not included in the study. Cost of land was also excluded.

C Results of the Analysis:

1 Sufficient data was not available to support the development of costs per unit of treatment, i.e., grit chamber, primary and final sedimentation tanks, digesters, etc.

2 Sufficient data was not available to support the separation of factory fabricated plants from field construction plants.

3 Relative costs between primary and secondary treatment decrease as the plants size increases.

4 Waste to be treated should dictate type of treatment, rather than cost, due to the relatively small difference in cost between types of treatment.

5 Cost estimating curves were developed for the following treatment processes:

- a Imhoff tanks
- b Imhoff type
- c Primary treatment
- d Stabilization ponds
- e Trickling filters
- f Trickling filters in conjunction with Imhoff type primary
- g Activated sludge

D The report sheds additional light on the question of sewage treatment plant costs, and factors influencing construction costs and is believed to be more truly authentic of waste treatment plant construction costs than any of its predecessors.

III SEWAGE TREATMENT PLANT CONSTRUCTION COST INDEX, PHS Publication #1069:

A The rapid increase in costs after World War II necessitated the use of a cost index to compare prices or costs from year-to-year, and from one geographic area to another.

B The Need for a Special Purpose Index for Sewage Treatment Plants:

1 A review of the general purpose indexes available in 1958 disclosed that there was no adequate basis for assuming that they could be used to accurately measure the changing cost of waste treatment plants, due to either a weight (quantity) or price bias.

2 The Engineering News-Record Construction Cost Index

a The ENR Index was in current use, it was simple, and generally well understood.

b A review of our cost data over a four-year period disclosed that the ENR was rising at about twice the rate that our unit cost of construction data was rising.

1) This could be explained by either the fact that our design and construction practices were improving at twice the rate that the ENR was rising, or that the ENR was too general for use with sewage treatment construction.

2) An analysis of the ENR Index base disclosed that it was too general for use with current sewage treatment cost data.

C The Weight and Price Bias of the Engineering News-Record

1 The ENR Index is based on pricing out:

200 hours of common labor - in 20 cities.

25 hundred weight of structural steel - from 3 miles - originally 2 1, 088 board feet dressed 2 × 4's.

6 barrels of cement - originally only Chicago price was used - in 1938 shifted to 20 cities.

2 The National index is computed form the arithmetic average of the 20 city prices. Thus a city that is experiencing an inflationary trend can distort the entire index.

3 The ENR does not include the most important commodities used in municipal waste treatment (process equipment and skilled labor); a quantity bias.

4 The ENR does not include cost of material in place or even on-the-job - a price bias.

5 The ENR uses a weight that is not representative of modern construction practices - a weight bias.

D Development of the Special Purpose Index

1 Alternate methods existed to devise the index.

- a Develop a composite from existing indexes eliminating weight and price biases - Inherent there would be considerable uncertainty as to the accuracy of the finished product.
- b Construct an econometric model from real price and quantity data which could be reviewed and rebuilt as the industry changed. It then becomes its own test for the base period.

2 Assumptions and base data

- a Hourly output of labor is constant.
- b The quantity and kinds of material used will remain constant and available.
- c Modern construction practices date back to the year 1930.
- d Engineering, legal, fiscal, and land costs as well as errors, omissions and deviations of the construction contract are excluded.
- e Base period for index is Federal base -- 1957-1959 = 100.

3 The econometric model

- a All new secondary type treatment plants approved under PL-660 and placed under contract prior to January 1963 served as the model.
    - 1) Statistically, they produce a plant as follows:
        - a) Design population 12, 000.
        - b) Contract cost/person $40.00.
        - c) Semi-aerated high rate trickling filter process.
        - d) Flow 1.34 mdg.
    - 2) This statistical model was then modified for design purposes as follows:

Design population	10,000	
Design flow	1.0-mgd	2.5-mgd maximum
BOD	200 mg/l	
High rate filter	recirculation $1\frac{1}{2}$ to 1	

Treatment efficiency based on BOD of not less than 92%.

3) Units of the model plant:

a) Comminutor, with bar screen

b) Parshall flume

c) Aerated grit chamber (allows for pricing out mechanical equipment for activated sludge)

d) Primary and final settling tanks

e) High rate trickling filter

f) Chlorine contact tank (also pre-Cl_2 facilities)

g) Primary and secondary digesters

h) Vacuum filter and control building (lab. included)

i) Auxiliary sludge drying beds

j) In-plant pumping station

4) Selected units combined to produce the statistical weighing of materials, labor, and equipment experienced under the PL-660 Construction program.

4 Pricing out the econometric model

a A Consulting Engineer was employed to actually design the econometric model, and do a complete labor, material, equipment, contractor's plant and expendable items take-off from the design, including profit.

b The Consultant's take-off was then re-arranged and combined so that nineteen selected prices could be used to historically price out the plant from 1930 through 1963.

1) The major problem remaining was pricing the process equipment over a time-period.

a) On the basis of raw materials to factory prices plus a fill factor, an index for process equipment was developed.

b) It accurately reflects the equipment manufacturer's cost experience over the past fifteen years.

c Using the re-arranged Consultant's figures plus fill values, total costs for each category of construction were computed, for the thirty-six months of 1957-1959. There average values were then equated to 100.

1) By recomputing these values each month, dividing them by the base average value and multiplying by 100, the index for the month is obtained.

d Twenty city indexes were developed in this fashion, so that each trading area has its own index independent of the effects of costs in other parts of the Nation.

e The National index was developed using the average plant cost for each of the 20 Trading Areas so that it is always the ratio of the 20 individual indexes to the base period, rather than a numeric average.

f It requires close to an hour to explain the mathematics involved, about 40 hours to compute the index by hand, and less than three minutes to compute the index using automatic data processing equipment.

E Trends and Projections of the Cost Index:

1 During the historic period (1930-1964) for every two points the Sewage Treatment Plant Index has risen, the Engineering News-Record has risen over three points.

2 Using 1930 as a base, the ENR increased to a value of 472 in 1964 compared to a value of 320 for the Sewage Treatment Plant index.

3 Future projections based upon trends indicate that the Sewage Treatment Plant index will increase at a rate of 2½% to 3% of the base value for the foreseeable future.

F Sewage Treatment Plant Cost Index Limitations

1 Costs of engineering, legal and fiscal services as well as land are not reflected by the index.

2 Sewers do not contain the same package of items, and consequently, the Public Health Service STP index is not applicable to them, (The Service therefore developed a separate index for sewers, PHS Publication #1132).

IV OPERATION AND MAINTENANCE COSTS AND PRACTICES

A Original O&M Survey

1 In 1959-1960, the Service surveyed 500 "well operated and maintained sewage treatment plants, with at least five years operational experience."

2 The results of this survey resulted in two publications:

a "Estimating Sewage Treatment Plant Operation and Maintenance Costs" which is a presentation of actual costs reduced to estimating curves.

b "Recommendations for Minimum Personnel, Laboratory Control and Records for Municipal Waste Treatment Works", which has been adopted by several states and used as a guide by others.

B Performance Audit Programs

1 In order to ascertain the degree of compliance with the regulations of PL-660, a program to visit each plant built under the Act was undertaken in 1961.

2 The data obtained from over 1,500 plants is currently being analyzed and will be published this summer.

C Preliminary Survey Results

1 Over three-fourths of the plants in the Study meet the minimum recommendations of the Conference of State Sanitary Engineers.

2 Largest single short-coming found was in operation practices, which could generally be corrected through state action (usually the operator did not understand, or know what should be done).

3 The severest problem encountered was the amount of raw sewage bypassed on a routine basis.

4 Approximately 20 percent of the plants operational or maintenance difficulties, but these were basically the better staffed and operated plants. (Might indicate a lack of knowledge on the part of the other plants. (Most difficulties had been corrected or were later corrected through state action).

5 The typical plant surveyed had no knowledge of the industrial wastes they were treating, other than possibly the number of industries contributing wastes to the collecting systems.

6 Municipal expenditures for waste treatment plant operation and maintenance were more closely allied to the population served, than to the type of treatment plant, or the degree of treatment provided, except in the case of waste stabilization ponds.

7 A preliminary comparison of cost results for principle categories of treatment are:

Category	Base unit	Cost/person/year	Cost/mgd
Primary	10,000 people	25.54	46.46
Secondary	or	34.44	70.78
Stabilization pond	1-mgd	.894	18.85

V SUMMARY

A Width of estimating curves tend to overlay each other, so that some primaries are more expensive than average secondary and some secondaries less expensive than average primary. The Public Health Service reports on construction, operation, and maintenance cost provide a partial answer to the question How Much Does Sewage Treatment Cost?

B As additional data is obtained the Public Health Service studies will be extended in the hope that additional light can be shed on the problem.

C This discussion has been limited to some of the data currently available from the Service. However, other sources are available and should be utilized in the examination of any particular problem.

REFERENCES

1 Rowan, P.P., Jenkins, K.H., and Howells, D.H. Estimating Sewage Treatment Plant Operation and Maintenance Costs. Journal Water Pollution Control Federation, Vol. 33, No. 2, pp 111-121.

2 Modern Sewage Treatment Plants - How Much Do They Cost? PHS Publication #1229. U.S. Government Printing Office. 1964.

3 Sewage Treatment Plant Construction Cost Index. PHS Publication #1069. U.S. Government Printing Office. 1963.

4 Sewer Construction Cost Index. PHS Publication #1132. U.S. Government Printing Office. 1964.

5 Conference of State Sanitary Engineers — Recommendations for Minimum Personnel, Laboratory Control and Records for Municipal Waste Treatment Works. DHEW, PHS, Washington, D.C. 1963.

This outline was prepared for the Training Program by Paul W. Reed, Chief, Construction Grants Branch, Public Health Service, Division of Water Supply and Pollution Control, Washington, D.C.

FEDERAL WATER POLLUTION CONTROL FIELD LABORATORIES

I HISTORICAL BACKGROUND

II LOCATION AND AREAS TO BE SERVED

III TYPICAL PHYSICAL LAYOUT

IV LIBRARY AND REFERENCE SERVICES

V TYPICAL ADMINISTRATIVE ORGANIZATION

A Within the Public Health Service

B Individual Laboratory

  1 Office of Director

  2 Research

  3 Technical services

  4 Training

VI INDIVIDUAL LABORATORIES-DESCRIPTION AND PROGRAM

A Alaska (College, Alaska)

B Pacific Northwest (Corvallis, Oregon)

C Robert S. Kerr (Ada, Oklahoma)

D Southeast (Athens, Georgia)

E Northeast (Boston, Mass.)

F Mid-Atlantic ( )

G Mid-West (Ann Arbor, Michigan)

VII OPERATING RELATIONSHIPS

This outline was prepared for the Training Program by D. H. Howells, Special Assistant for Field Laboratories, Public Health Service, Division of Water Supply and Pollution Control, Washington, D. C.

Outline Number

LEGAL ASPECTS OF WATER QUALITY MANAGEMENT

Implementing Enforcement Actions at the Public Health Service Regional Level 74

An Eastern State Enforcement Program

Prior Appropriation and Quality Control 76

Interstate Compacts 77

IMPLEMENTING ENFORCEMENT ACTIONS AT THE PUBLIC HEALTH SERVICE REGIONAL LEVEL

Enforcement measures against pollution of interstate or navigable waters are carried out under Section 8 of the Federal Water Pollution Control Act, as amended (PL 87-88). It is to be noted that the amended Act approved July 20, 1961 strengthened this section of the law and broadened its provisions. The word "navigable" was introduced and the number of steps in the enforcement action was increased from two to three. The two steps under PL 660 approved July 9, 1956 were a hearing and court action. The present Act calls for a third step, an initial conference action.

The purpose of the enforcement provisions of PL 87-88 is to bring about the abatement of the pollution of interstate or navigable waters, in or adjacent to any state or states, which endangers the health or welfare of any persons. This Section of the law applies to pollution discharged directly into such waters or reaching such waters after being discharged into a tributary of such waters. The initiation of any action under this Section is the responsibility of the Secretary, DHEW. The Secretary may initiate enforcement action in any one of the following ways:

A Whenever requested by the Governor of any state or a State Water Pollution Control Agency or (with the concurrence of the Governor and of State Water Pollution Control Agency of the state in which the municipality is situated) the governoring body of any municipality if such request refers to pollution of waters which are endangering health or welfare of persons in a state other than that in which the pollution originates.

B Whenever requested by the Governor of any state if such request refers to pollution of interstate or navigable waters which is endangering the health or welfare of persons only in requesting state in which pollution originates. A conference is to be called unless in the judgment of the Secretary, the effect of such pollution on the legitimate uses of the waters is not of sufficient significance to warrant exercise of Federal jurisdiction.

C Whenever, on the basis of reports, surveys, or studies, he has reason to believe that any pollution of interstate or navigable water is endangering the health or welfare of persons in a state other than that in which the pollution originates.

Before the passage of the 1961 amendments, 15 enforcement actions had been initiated. Since July 1961, 21 additional enforcement actions have been initiated. None of the actions since July 1961 have gone to the hearing stage and only one of the pre 1961 actions has proceeded to a near court action. However, the one case of pollution in which court action was initiated was abated before brought into Federal Court.

The responsibility of the Regional Office is to gather the necessary facts and give assistance regarding technical problems on interstate pollution. For many years these facts have been compiled into Summary Reports which are periodically updated to show improvements or changes in the interstate pollution problems. A Summary Report has been or will be prepared for each interstate stream in the country. Also, when any complaints are registered with the Program, the Regional Office ascertains the facts of the case and obtains information as to what steps are being taken to correct conditions leading to the complaint. When the complexity of the situation warrants, field studies are recommended to determine the nature of the pollution problems and their effects on health and welfare.

When an enforcement conference is called by the Secretary under any of the three steps mentioned earlier, the Act requires that conferees at the conference determine:

A Occurrence of pollution of interstate or navigable waters subject to abatement under this Act.

B Adequacy of measures taken toward abatement of the pollution.

C Nature of delays, if any, being encountered in abating the pollution.

Following the Conference, if the Secretary believes that effective progress toward abatement of such pollution is not being made and that health and welfare is being endangered, he recommends to the appropriate State Water Pollution Control Agency that it take necessary remedial action. Many times the remedial action recommended is such that technical assistance is needed from the Water Supply and Pollution Control Program. The Regional Office then works closely with the state agencies in providing technical assistance needed to further assess the problem and determine solutions.

One of the most difficult problems facing the state, local communities, and industries is the financing of wastes treatment facilities. The plan of financing must be determined locally. However, since Federal fincancial assistance is also available, the time schedule for abatement should consider all sources of funds. Such time schedules must be realistic in terms of time needed to make planning studies, draft engineering plans and specifications, and coincide with reasonable financial plans of the community and industry. These schedules are reviewed by our Staff to determine if they are reasonable to all concerned.

Once a time schedule is established this is incorporated into the Secretary's recommendations. As a follow-up of enforcement actions, the Regional Program makes semi-annual reports on the progress being made. In this way an evaluation can be made as to whether pollution abatement measures are being provided as recommended by the Secretary.

In all of these Programs it must be realized that this is a cooperative action being taken to assist the states in resolving problems which, because of multiple state responsibility, they have little control. Also in those cases where the problem is intrastate in nature, it often becomes necessary to seek outside Federal assistance to obtain corrective measures. Since pollution problems are complex, in many cases involving a number of Federal agencies, more than one state and many industries and municipalities, we must work together to solve them. We in the Regional Offices and the Federal Program view the interstate pollution problems as one requiring the continued cooperation of governments at all three levels, federal, state, and local. We wish to pledge our cooperation as a member of this team to solve the problem.

This outline was prepared for the Training Program by Herbert H. Rogers, Regional Program Director, Water Supply and Pollution Control, Public Health Service, Region IV, Atlanta, Georgia.

PRIOR APPROPRIATION AND QUALITY CONTROL

I INTRODUCTION

A History

Prior appropriation evolved as an offshoot of mining law in California, spread to agriculture, was codified by statute and adopted as the dominant form of law applicable to the surface streams of the 17 western states and Alaska.

B Definition

An appropriation is a property right. It is the right to use a specific quantity of the water of a public source of supply, if that quantity is available free from the claims of prior appropriators.

II APPROPRIATION DOCTRINES

A Priority

A water right is given a specific date, generally the date on which the project was initiated. As the quantity of water in a stream decreases, the diversion works of the appropriators are shut off in inverse order of priority. The last ditch is the first closed, the earliest is never closed. If the stream rises, water users are allowed to take water in order of seniority. The burden of shortage falls on those with the later rights; there is no proration in times of scarcity; and the senior rights are supplied in full while the junior rights are shut off completely. The right of the senior appropriator extends both upstream and downstream. Junior appropriators who take water from a source that has already been partially appropriated get the right to use such water as is not needed to satisfy the rights of senior appropriators.

B Diversion

Generally, an appropriation requires a diversion of the water from the stream, or the interruption of the flow by a dam which stores the water for later use.

C Beneficial Use

The water must be appropriated for a beneficial use. There is no closed category of such uses. Uses which have been approved are domestic, municipal, irrigation, mining, manufacturing, power production and several other types of utilitarian applications. In modern times a new beneficial use, recreation, has been recognized. A use must not only be embraced within the general class of beneficial uses, but it must also be a reasonable and economic use of the water in view of other present and future demands upon the supply.

D Quantity

An appropriation is the right to take a definite amount of water. Direct flow rights are stated in terms of the maximum current or flow that may be diverted from the stream, and storage rights are expressed in terms of the total volume of water that may be stored. The upper limit is the quantity of water reasonably necessary to accomplish the beneficial use to be served by the appropriation.

E Sale and Change

A water right is property that can be sold by its owner and put to a different use at a different place by the purchaser. Such changes must not injure the vested rights of other appropriators. Typically, this means that when an irrigator sells his water right to a city or industry, only the amount of his consumptive use, not the amount of his total diversion, may be changed.

Preferences given to certain types of water use do not entitle the preferred user to take water out of priority, but only to condemn and pay for a prior non-preferred use.

F Permits

In nearly all states, a person wishing to appropriate must obtain a permit from a state water official. The permit may be denied if the proposed use of the water will not be in the public interest.

III RELATION TO QUALITY CONTROL

A No Appropriation of Quality

Prior appropriation law deals with quantity, not quality, of water.

1 An appropriator whose use deteriorates the quality of the water returned to the stream does not obtain a prior right to continue his use if it prevents beneficial use by subsequent downstream appropriators.

2 An appropriator does not obtain a prior right to water quality that cannot be impaired by later upstream users. He must look to other laws for his protection.

B Flows For Dilution

Water may not be appropriated in place, without diversion, to dilute discharges of wastes. But:

1 Unappropriated water probably may be reserved from appropriation, so that minimum flows may be maintained, by the denial in the public interest of permits for future appropriations that might take such minimum flows.

2 Water may probably be appropriated for storage in reservoirs and released to maintain minimum flows, if such use would be reasonable and beneficial in view of other needs for the water and other methods of quality control.

3 Consumptive users of water, with appropriative property rights, cannot be simply shut off if water is needed for dilution. But with enabling legislation, rights could be condemned and paid for.

IV CONCLUSION

The law of prior appropriation was developed without reference to quality control. Pollution control laws have evolved independently. Coordination of the two is possible by the intelligent application of existing prior appropriation principles, or by new legislation which would fit into the existing framework of appropriation doctrine.

This outline was prepared for the Training Program by Professor Frank J. Trelease, University of Wyoming, College of Law, Laramie, Wyoming.

INTERSTATE COMPACTS

I NATURE OF COMPACTS

A An interstate compact is a statute in each of the party states.

B It is also a contract among the party states.

C Compacts are enforceable in both federal and state courts.

II DEVELOPMENT AND USE OF COMPACTS

A Until the 1920's they were used almost entirely for negotiated boundary settlements among the states. The only exceptions related to the financial settlement attending the admission of West Virginia into the Union and the Virginia-Maryland, Oregon-Washington and Delaware-New Jersey Fisheries Compacts.

B Pioneering use was made of interstate compacts for interstate administration.

1 The Colorado River Compact provided for an apportionment of water between the Upper and Lower Basins and is administered by the state engineers in the party states.

2 The Port of New York Authority Compact creates a bi-state agency for construction and operation of public works.

C Compacts are now used for a wide variety of cooperative projects and programs among the states, and in the instance of the Delaware River Basin Compact, even of the states and the federal government. Some of the subjects dealt with by compacts are water pollution control, air pollution control, conservation of oil and gas, forest fire protection, fisheries administration, social welfare, crime control, and cooperative use of institutions.

III USE OF COMPACTS FOR WATER POLLUTION CONTROL

A The Interstate Sanitation Commission established by the Tri-State Compact (New York, New Jersey and Connecticut) in 1936 is the oldest of the several pollution control compacts.

1 The Commission has classified all the waters within its jurisdiction.

2 The compact contains specific standards measured in terms of the quality of the effluent and in terms of dissolved oxygen content of the waters.

3 While the Interstate Sanitation Commission proceeds by research, negotiation and recommendation as a first resort, it also has power to abate pollution by court action and has done so in more than a dozen instances.

B The Ohio River Valley Water Sanitation Compact has the largest number of party states of any interstate pollution control compact. All of the eight states in the Ohio River Basin are parties to it. The Ohio Valley agency has much the same powers as the Interstate Sanitation Commission, but it has not engaged in litigation.

C The Tennessee Compact has a potential of seven party states, three of whom (Kentucky, Tennessee and Mississippi) have so far enacted.

D The New England and Potomac Compacts are recommendatory only, except that the former gives the compact commission power to classify waters. They proceed by study and negotiation.

E The Delaware River Basin Compact establishes a Commission with comprehensive water planning and management power, including regulatory authority in the field of pollution control. This commission and the compact establishing it is worthy of special note because the federal government, as well as the four states of the Delaware Basin, is a full party. Consequently, the compact combines both state and federal power.

IV COMPACTS AND THE FEDERAL GOVERNMENT

A 1 The United States Constitution in Article I, Sec. 10, Cl. 3 provides that "No state shall, without the consent of Congress... enter into any agreement or compact with another state or with a foreign power."

2 Despite this provision, the United States Supreme Court has decided that only certain types of compacts need Congressional consent. These might or might not include water pollution control compacts, but federal statute requires specific consent for compacts of this type.

B The Federal Water Pollution Control Act directs the Department of Health, Education, and Welfare to encourage the development of interstate compacts for water pollution control.

C The requirement in the statute for specific consent to pollution control compacts, once negotiated, is a restriction rather than an encouragement.

V VALUE OF COMPACTS AS A MEANS FOR WATER QUALITY REGULATION

A 1 Many watersheds are interstate in character.

2 Single jurisdictions may not act in concert in the absence of a formal agreement to do so.

B A compact is binding on both upstream and downstream jurisdictions.

C The record shows that states take compact obligations seriously.

REFERENCES

A brief running account of compact developments appears in the Book of the States published biennially by the Council of State Governments. Book length treatments of the subject which contain comprehensive information on all phases of compact law and practice are:

1 Zimmerman, Fred L. and Wendell, Mitchell. Manual of the Law and Use of Interstate Compacts. Published for the National Association of Attorneys General of the Council of State Governments. 1961.

2 Zimmerman, Fred L. and Wendell, Mitchell. The Interstate Compact Since 1925. Council of State Governments. 1951.

3 Leach, Richard H. and Sugg, Redding S. The Administration of Interstate Compacts. Louisiana State University Press. 1959.

This outline was prepared for the Training Program by Mitchell Wendell, Counsel, The Council of State Governments, Washington, D. C.

	Outline Number
COMPUTERS IN WATER QUALITY MANAGEMENT	
Storage and Retrieval of Basic Data - The STORET System	78
Calculator or Computer - Management's Consideration in Data Processing	
Application of Systems Analysis	

STORAGE AND RETRIEVAL OF BASIC DATA - THE STORET SYSTEM

I NEED FOR COMPUTER HANDLING OF WATER QUALITY DATA

A Computers provide the most efficient means of handling the large volume and variety of water quality and related data being collected today.

B Finding, extracting, and summarizing desired data is difficult, time consuming, and expensive using clerical methods.

C More data are being generated now and more sophisticated analyses are being performed on it.

D Automatic Data Processing provides a rapid and efficient means for storage and retrieval of data for visual examination and for further processing.

II STATUS OF PUBLIC HEALTH SERVICE STORET SYSTEM

A Sub-Systems Using River Mile and Index for Point Location

1 Sub-system I for handling chemical, physical and related data is in operation.

2 Sub-system III for handling water and waste facilities data is being programmed and will be in operation in late 1965.

3 Sub-system V for handling biological data is in the design stage and will go into operation in 1966.

B Sub-Systems Using Geographic Co-Ordinates For Point Location

1 Sub-system II for handling chemical, physical and related data will be in operation by about June, 1965.

2 Sub-system IV for water and waste facilities data and sub-system VI for biological data will be programmed following completion of the other sub-systems.

C Computational Programs

1 Statistical analysis programs written

2 Program completed for calculating weight of material passing a point in a stream.

III OPERATION OF STORET SYSTEM

A Designed for Public Health Service Use

1 Flexibility built in to allow handling of data collected by other organizations.

B Computer Facilities of R. A. Taft Sanitary Engineering Center Used

C Field Offices Perform Necessary Coding and Send Data to the Computer Center for Processing.

D Headquarters Unit Writes Basic Computer Programs and Co-Ordinates Activities

IV ELEMENTS OF STORET SUB-SYSTEM I

A River Mileage and Index Method of Sampling Point Location is Used to Permit Hyrologic Listing of Data.

B Considered as the Basic Element in Total STORET System.

C Location Coding Elements

1 Terminal major and minor basins used as first elements in station location.

2 Terminal stream numbers assigned to each stream flowing into oceans or large lakes.

3 Mileage and index numbers determined for stream confluence points throughout the river system.

4 Special maps prepared for coding.

5 Coding completed in some basins and is in progress in several others.

D Station Location Procedure

1 Station numbers assigned to sampling points.

2 Appropriate basin numbers plus river mileage and index data which identify the location of the sampling point are entered in computer.

3 Descriptive data and codes describing type of station and agency operating the station also entered.

4 Station location data are entered in the system only once for each station.

E Water Quality Data Storage Procedure

1 Parameter numbers have been assigned to each parameter of interest in water quality work.

2 Compilation of parameters and associated parameter numbers has been prepared.

3 Use of parameter numbers allows flexibility in handling data.

4 Data entered in system using floating point technique.

5 Fixed field cards can also be used for entering data.

F Data Retrieval

1 Methods of selecting stations for which data are to be retrieved.

a Specify by station number

b Specify that stations above a point be retrieved.

c Specify that stations below a point be retrieved.

d Combination of (b) and (c)

e Retrieval can be limited to certain states, agencies or types of station.

2 Parameters to be retrieved

a Specify up to 50 per computer run

b Ten parameters may be listed per page and arranged in any desired order

3 Retrieved data can be printed on paper or written to magnetic tape for further processing.

V ELEMENTS OF STORET SUB-SYSTEMS UNDER DEVELOPMENT

A STORET Sub-System II

1 Main application will be in coastal and estuarine studies, reservoir and lake studies, and ground water studies.

2 Sampling points located by latitude and longitude.

3 Parameters identified and handled in the same manner as in existing STORET sub-system I.

4 Station retrieval

a Stations within a specified rectangle.

b Stations within a circle defined by center point and radius.

c Stations within a specified distance of a series of vectors.

d Retrieval can be limited to land or water stations, stations of a certain type, or stations operated by a certain agency.

B STORET Sub-System III

1 River mileage and index method used to identify points.

2 Data consists of information on water supply and waste water disposal facilities.

3 A system is now in existance for storing and retrieving data using the RCA - 301 computer.

4 Existing system will be expanded and modified to allow hydrologic listing.

C STORET Sub-System IV

1 River mileage and index method used to identify sampling points.

2 Sub-system is designed for handling biological data.

3 Biological organisms will be assigned parameter numbers in accordance with their taxonomic classification, thus permitting retrieval of data by phylum, class, etc.

D STORET Sub-Systems IV and VI

1 Sub-systems IV and VI will handle water and waste facilities data and biological data respectively.

2 Points will be located by latitude and longitude.

VI OPERATING CONCEPTS AND GOALS

A STORET System is Considered as a Part of an Integrated System For Data Collection, Processing, Analysis, and Reporting.

B Fundamental Concepts of an Integrated System.

1 Continuous input of raw data into a data processing system.

a Conventional data collection methods

b Automatic monitors

2 Selected data will be retrieved from the processing system, combined with other facts, and fed to analytical systems.

3 Analytical systems such as mathematical models will provide decision makers with digested information on trends, forecasts, optimum solutions, etc.

C Status of Integrated System

1 Many automatic monitoring devices installed and functioning.

2 Most needed STORET sub-systems now or soon will be in operation.

3 Mathmatical models being used in such studies as Delaware Estuary Comprehensive Study

D Future Requirements

1 Expansion and refinement of monitoring devices, STORET System and especially mathmatical models.

2 Improved co-ordination of individual elements through better communication.

a Faster communication

b Ready access of computer systems to more users.

c Improved compatability of data format and computer language.

This outline was prepared for the Training Program by Donald P. Dubois, Acting Director, Data Operations System, Basic Data Branch, Water Supply and Pollution Control, Public Health Service, Washington, D. C.

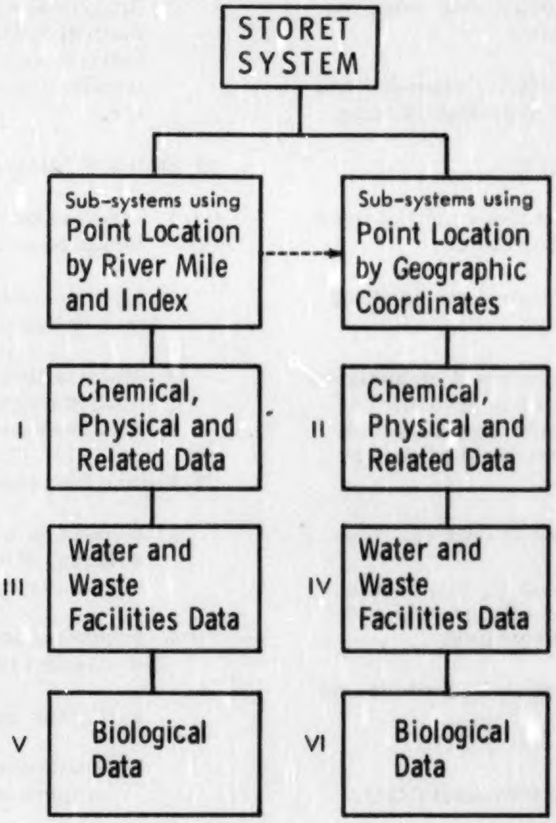
STORET SYSTEM
Sub-systems using Point Location by River Mile and Index
Sub-systems using Point Location by Geographic Coordinates
I
Chemical, Physical and Related Data
II
Chemical, Physical and Related Data
III
Water and Waste Facilities Data
IV
Water and Waste Facilities Data
V
Biological Data
VI
Biological Data

Figure 1

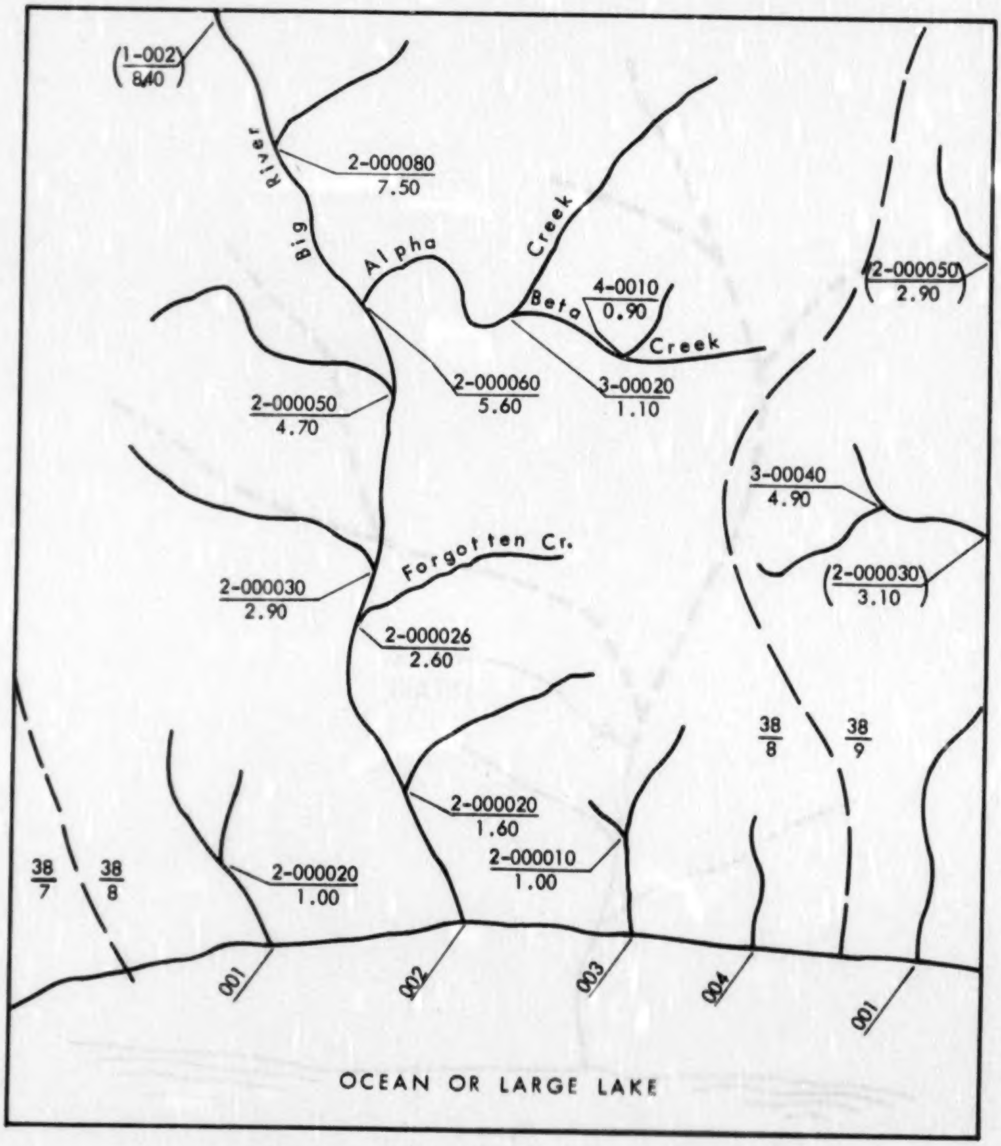
(1-002)
8.40
Big River
2-000080
7.50
Alpha Creek
Beta
4-0010
0.90
Creek
2-000060
5.60
3-00020
1.10
2-000050
4.70
2-000050
2.90
3-00040
4.90
Forgotten Cr.
2-000030
2.90
(2-000030)
3.10
2-000026
2.60
38
8
38
9
2-000020
1.60
2-000010
1.00
38
7
38
8
2-000020
1.00
001
002
003
004
001
OCEAN OR LARGE LAKE

Figure 2
River Mile and Index Coding for STORET Sub-systems

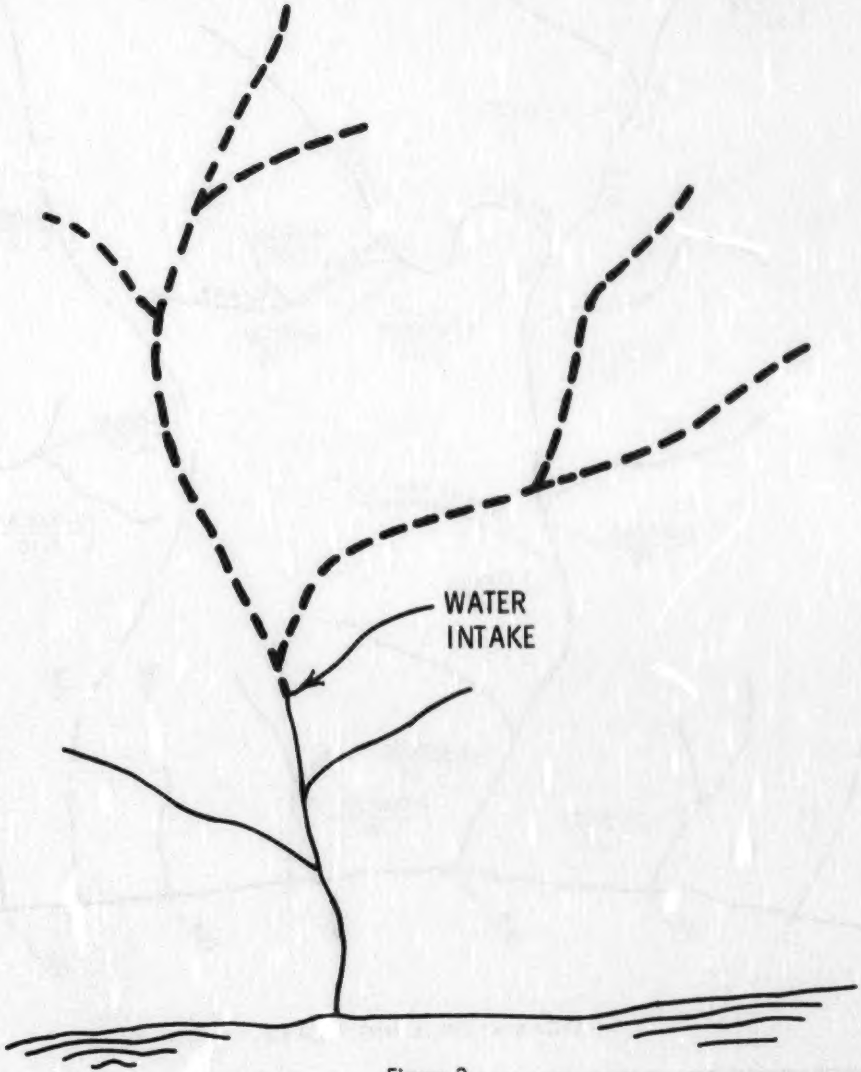

Figure 3
Retrieval Above a Point for River Mile-Index Sub-systems

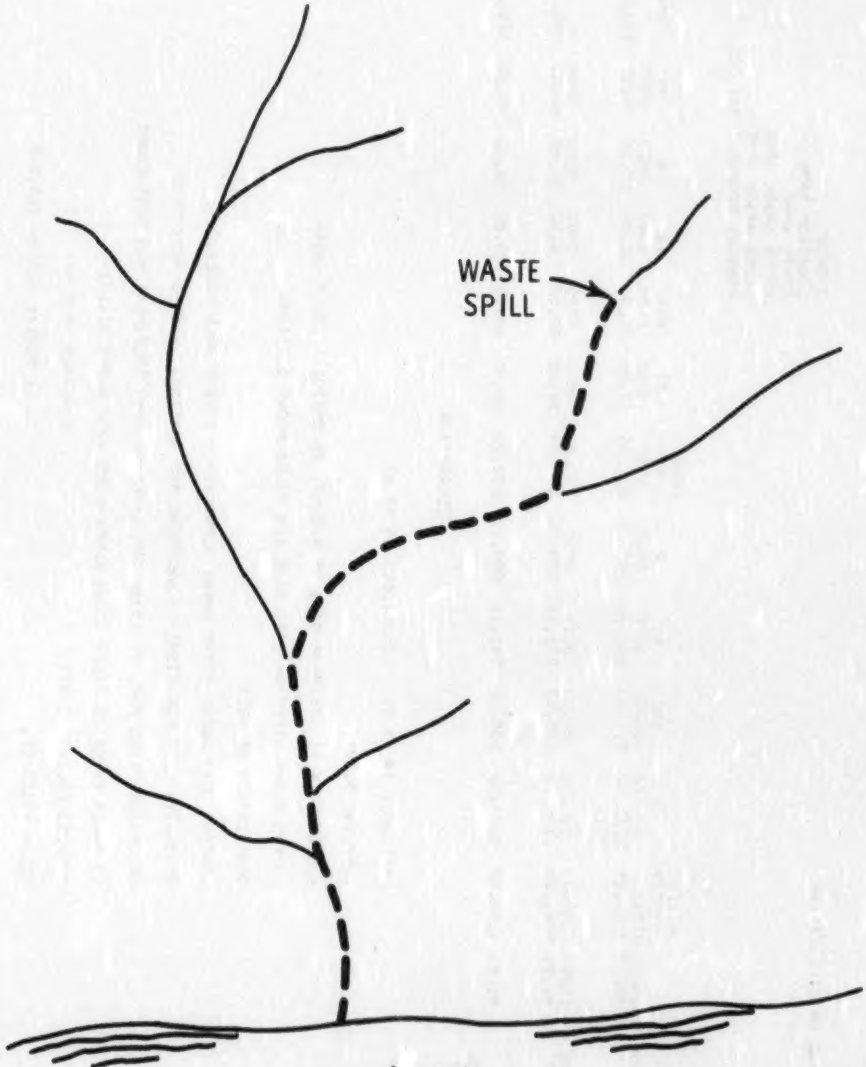

Figure 4
Retrieval Below a Point for River Mile-Index Sub-systems

```
RETRIEVAL DATE: 10/26/64                                                                     390003
                                                                                             LOCATION NAME
                                                                                             STATE NAME
                                                                                             MAJOR BASIN NAME
                                                                                             MINOR BASIN NAME
                                                                                             AGENCY: 000000 TYPE: 002

                   RIVER                                        LEVEL
                   SYSTEM       II        III      IV       V        VI       VII     VIII     IX       X        XI       TOTAL
  STATION    INDEX 5110003    000020    00000     0000     0000     0000     0000     0000     0000     0000     0000
             MILES 0181.25    0121.00   000.00   000.00   000.00   000.00    00.00    00.00    00.00    00.00    00.00    0302.25


  CONTROL    INDEX 5110003    000020    00010     0020     0000     0000     0000     0000     0000     0000     0000
   POINT     MILES 0181.25    0178.00   100.02   041.11   000.00   000.00    00.00    00.00    00.00    00.00    00.00    0500.38

  STATION
    TO       MILES 0000.00    0057.00   100.02   041.11   000.00   000.00    00.00    00.00    00.00    00.00    00.00    0198.13
  CONTROL
   POINT
                                                      DESCRIPTION

                    LATITUDE: 39 17 41   LONGITUDE: 86 37 42

                    SAMPLING POINT:

                    ALPHA RIVER AT UPSTREAM SIDE OF HIGHWAY 26 BRIDGE.  BOLLA CREEK

                    ENTERS ALPHA RIVER ON LEFT SIDE 0.3 MILES ABOVE STATION.

                    DESCRIPTION OF AREA:

                    STATION JUST ABOVE POINT WHERE ALPHA RIVER ENTERS BELL RESERVOIR.

                    RESERVOIR USED FOR FISHING, SWIMMING AND BOATING.  WASTES FROM TOWN

                    OF ORANGE (1960 POP. OF 1320) ARE GIVEN PRIMARY TREATMENT AND DISCHARGED

                    TO BOLLA CREEK 15 MILES ABOVE CONFLUENCE WITH ALPHA RIVER.

                    SAMPLES COLLECTED BY:                           ANALYSES MADE BY:

                    DELTA POWER CO.                                 U. S. PUBLIC HEALTH SERVICE
```

Figure 5

```
RETRIEVAL DATE: 10/26/64
                                                                               380003
                                                                               LOCATION NAME
                                                                               STATE NAME
                                                                               MAJOR BASIN NAME
                                                                               MINOR BASIN NAME
                                                                               AGENCY: 000000 TYPE: 002
                       00007     00001     00003     00010     00610     00620     00615     00660     31503
 DATE      TIME      SAMPLES   HSAMPLOC  VSAMPLOC    WATER    AMMONIA   NITRATE   NITRITE   ORTHOPO4  COLIFORM   (PAR. NO.)
 FROM       OF          IN     FT FROM    DEPTH      TEMP     NH3-N     NO3-N     NO2-N      PO4     DLY ENDO   (         )
  TO       DAY      COMPOSIT   RT BANK     FEET      CENT      MG/L      MG/L      MG/L      MG/L    MF/100ML   (PAR ABBR)
                                                                                                              (         )
11 05 62  11 45                    30         5      10.0     0.146      1.62     0.016      0.19        10K     DATA
11 05 62  11 47                    30        10       9.9     0.172      1.85     0.019      0.22        500    FIELD:
11 05 62  11 55                    60         5      10.1     0.188      2.06     0.021      0.26        840
11 05 62  11 57                    60        10      10.0     0.175      2.03     0.018      0.22       1120   8 digits
11 05 62  12 00                    90         5      10.5     0.216      3.42     0.036      0.31      3000L   including
11 05 62  12 02                    90        10      10.3     0.209      3.09     0.027      0.28      3000L   decimal
11 12 62                  6                                   0.180      1.98     0.020      0.17               point
11 12 62  C
11 19 62                  6                                   0.174      1.01     0.016      0.15
11 19 62  C
11 26 62                  6                                   0.182      2.06     0.024      0.19
11 26 62  C
12 03 62                 12                                   0.176      1.85     0.022      0.18              REMARKS
12 10 62  C                                                                                                   FIELD:
12 17 62                           60         5       7.2     0.166      1.72     0.019      0.16       1320   1 digit
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Figure 6

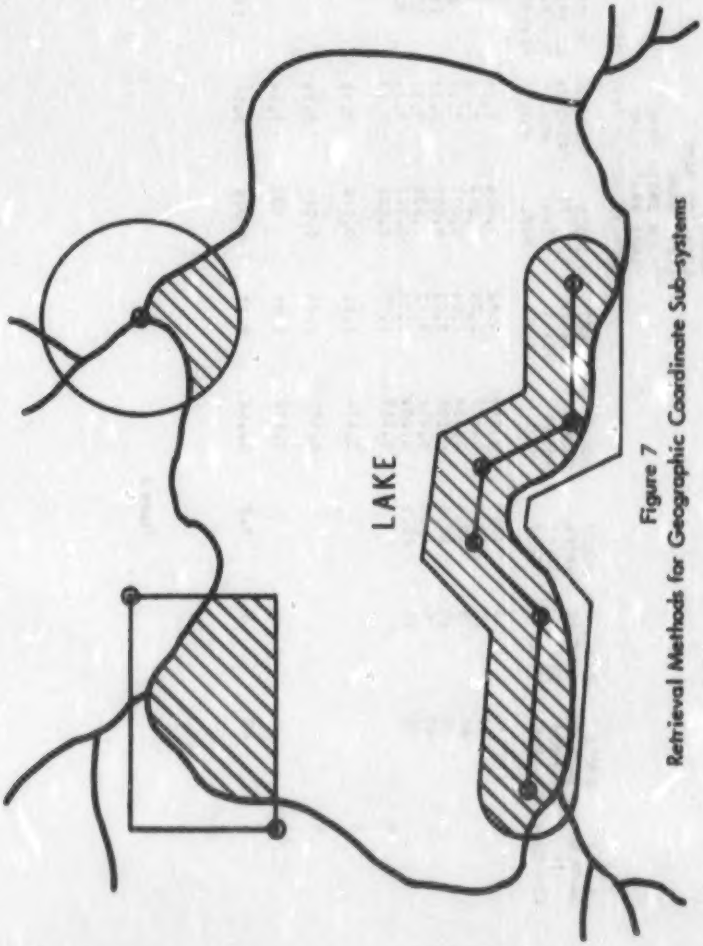

Figure 7
Retrieval Methods for Geographic Coordinate Sub-systems